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WOMEN OF MODERN SCIENCE

EDNA YOST

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WOMEN OF MODERN SCIENCE

LADDER EDITION
published November 1963

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To F B H

For a half-century of friendship

S.C.E.R.T., West Bengal
Date 8-1-87
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CONTENTS

Page

1. *Gerty Theresa Cori* 9
2. *Lise Meitner* 16
3. *Helen Sawyer Hogg* 24
4. *Elizabeth Shull Russell* 33
5. *Rachel Fuller Brown* 41
6. *Chien Shiung Wu* 49
7. *Edith Hinkley Quimby* 57
8. *Jocelyn Crane* 64
9. *Florence Van Straten* 71
10. *Gladys Anderson Emerson* 79
11. *Dorothea Rudnick* 86
Glossary 94

GERTY THERESA CORI
(1896-1957)

The only American woman to win a Nobel Prize in science

There are three Nobel Prizes in science. One is in chemistry, one is in physics, and one in physiology and medicine. They have been given every year since 1901 and are regarded as the world's highest prizes in science. Only three women have received them.

In 1947 the honor came to America for the first time when Carl and Gerty Cori received half the Nobel Prize in Physiology and Medicine. At that time they were working at the Washington University School of Medicine in St. Louis, Missouri. The Coris were born in Austria, but they became Americans by choice soon after finishing school in Prague. As Americans they found opportunity to do all the work that won them the Nobel Prize, and they had been American citizens for almost twenty years when they received their great honor.

This is the story of a girl called Gerty Theresa Radnitz, who grew into the woman who earned her share of that prize. Her life and work were so much a part of her husband's that it is not possible to tell about one without the other.

Her life was one of the happiest and most purposeful that any woman could live. As a wife and mother she enjoyed a woman's great pleasure in making a happy home. As a scientist she enjoyed working on difficult problems that needed a well-trained mind and a good imagination. As a warm and kind human being she loved and was loved by friends all over the world. As a woman she endured ten years of illness without losing her courage and dignity. In fact, she grew in human understanding by her acceptance of suffering. She lived to see her work on health and illness receive high honors. The rewarding experiences that life held for her were surely beyond anything she could have imagined when she decided to study medicine at the age of sixteen.

To begin at the beginning, Gerty Radnitz was born in Prague, a city that was then in Austria. Her father was the manager of several factories. She studied at home until she was ten years old. Then, like most other girls of her social group, she went to a school for girls. Its aim was to prepare young women to be wives and mothers. Science and mathematics were not very important in the school's studies.

But Gerty Radnitz could not accept limits to the development of her mind. By the time she was sixteen she had decided to study medicine. However, she discovered that before she could begin medical school, she needed chemistry and physics, five years of mathematics, and eight years of Latin, a language used by doctors all over the world.

All this could be done at a Gymnasium, a higher school where most of the students were boys. However, she could be accepted if she could do the work. After the Gymnasium, medical school would take another six years. The 16-year old girl must have thought she would be a gray-haired old woman before she became a doctor. Being Gerty Radnitz, however, she decided to enjoy a summer's vacation before beginning her studies.

Vacationing in the mountains that summer, she met a man who was a Gymnasium teacher. When he heard Gerty's problems and plans, he suggested one day, "Then why not let me help you start in Latin this summer?" The other vacationers saw less and less of the pretty brown-eyed girl with the reddish-brown hair. By the time her vacation was finished, Gerty Radnitz had completed three years of Latin. In one year at the Gymnasium she completed all the work needed to prepare her for the entrance tests for medical school. She did not fail the tests. All her life she spoke of them as the hardest tests she ever had to take.

Just after her eighteenth birthday she entered the medical school at the University of Prague, one of the oldest and most famous universities in Europe. A tall blue-eyed young man named Carl Cori also entered the university that year. Soon the two medical students met. After a while they began to do research together in biochemistry, a subject which interested Gerty very much. They enjoyed working together, and they enjoyed seeing their work published bearing both their names.

They also discovered they enjoyed each other outside of school. It was fun climbing mountains and swimming together. Soon they were in love. They finished medical school in the spring of 1920 and married before the end of the summer.

While they were in medical school, World War I had been fought. And for Austria it had been lost. The future did not look hopeful for two young doctors who wanted to do research in biochemistry.

For two years they lived in Vienna, where Carl did research and Gerty worked at a children's hospital. But neither Gerty nor her husband felt that Europe offered good opportunities for the kind of research they wanted to do. To them, America seemed a land of hope. They tried to find a way to go there.

Two years after finishing medical school, Carl Cori obtained a job as a biochemist at an institution for the study of diseases in Buffalo, New York. He came to America alone. After a few months he found a job for his wife at the same institution. So it was in America that these two were again able to work together as they had in medical school. After that time (1922) most of their work was done as a team.

Their training in medicine and physiology had prepared the Coris for research about the biochemistry of human bodies. The institution in Buffalo gave them all they needed for their research and complete freedom to do the work. In her later life Gerty Cori said she was thankful for the "wonderful opportunities" she and her husband found in America.

Their early research at Buffalo was on the growth of masses not normal in the body. Other research was suggested by the discovery of insulin, a substance made in normal bodies to control the body's use of carbohydrates, which are substances found in certain foods such as sugar. To the Coris insulin was a new tool for finding out more about the processes going on in the human body. They fed a known quantity of sugar to animals and then gave insulin to some but not to others. After these and other similar experiments they discovered a process in the body now known as the "Cori cycle." They found that about half of the sugar was changed into a carbohydrate called glycogen. The glycogen was changed into other substances, and after other changes these substances again became glycogen. Their discovery added a great deal to man's understanding of the process of body growth.

In 1931 Washington University in St. Louis offered Carl Cori a job as a professor. Gerty Cori was a offered a job there doing research. They accepted, and later Gerty became an associate professor of biochemistry at the University. She became a professor shortly before they received the Nobel Prize. But teaching was never a very important part of her life work. She was much more interested in research.

In St. Louis Gerty worked in the laboratory as an equal with her husband. They talked about the problems in their work, decided what to do about them, and then divided the work between them. Each did his own work, alone or with students or other assistants. Then they discussed their work with each other so that each would know what progress the other was making.

During some of the time while Carl was busy with his teaching and other duties, Gerty was also busy in the home that meant so much to them. It was a home where plants and flowers grew well under Gerty's care and where good music and good pictures were enjoyed. And a few years after they arrived in St. Louis a son was born to them.

Gerty's work was planned so well that young Tommy scarcely interrupted his mother's research. Carl Cori had much to do with the way his wife's work continued during this time and in later years when she worked during periods of illness.

In St. Louis the Coris continued their work with glycogen. Some of the changes in glycogen that occurred during the Cori cycle were due to enzymes. The Coris' interest in these changes led to an important series of discoveries.

Very little was known about enzymes at that time. There is still too little known about them. It is believed that each enzyme usually acts on only one substance. The Coris discovered two new enzymes. They also discovered which enzymes act on glycogen during the Cori cycle. In her share of the work, Gerty Cori found four different glycogen diseases.

For their discovery of how glycogen is changed in the body, Carl and Gerty Cori received half of the Nobel Prize in Physiology and Medicine in 1947. The other half was given to Bernardo A. Houssay, a doctor in Argentina who was also studying the body's use of sugar.

A Nobel Prize honors work that has great importance. But the Coris' work was only part of what they gave to science. Their laboratory in St. Louis became a center for excellent scientists. Many studies of carbohydrate processes have been published by scientists who came to the center to work with the Coris.

It is possible that work that began at the center will lead to new knowledge about the diseases that affect many people in middle and later life. Some doctors believe that many diseases occur from eating too many foods containing carbohydrates. Work that began at the Washington University laboratory may lead to a greater interest in the better eating habits that would prevent these diseases.

Even before Gerty Cori accompanied her husband to Stockholm in 1947 to receive the Nobel Prize from Sweden's King Gustav V, she was attacked by a disease that science does not know how to cure. But for more than ten years she refused to let it stop her work. The days were gone when she and Carl could climb mountains together, but there was still the garden in St. Louis. Carl cared for the vegetables, and Gerty cared for the flowers. Young Tommy's duty was to pull out the weeds. The wide seats beneath the windows in her dining and living rooms became a garden in the house when Gerty had to spend more time at home.

During her illness she continued the reading that was a lifelong habit. Her interests went far beyond science. She read two or three books a month on history, the events of the present that make history, and stories of other people's lives. She was an unusually well-informed woman in any group that she was in. She saw art, as well as science, as one of the glories of the human mind.

And there were always friends. Even while she became weaker and weaker and every bit of her energy increasingly precious to her work, she gave her time to her friends. Her last letter was to a friend whose husband was ill. In it she expressed the hope that he would soon be better. Honesty, courage, and kindness were the virtues she admired most. In her later years she said that kindness seemed more important to her than it had in her youth. Kindness was a virtue her friends found in her. And it did not leave her in the years of her illness.

Many honors came to Gerty Cori, most of them after the Nobel Prize. She became the fourth woman member of America's National Academy of Science in 1947, eight years after her husband had been elected to that group. In 1946 she shared the Midwest Award in Science with her husband. Later she shared his second Sugar Research Prize. She was made an honorary doctor of science by Boston and Yale Universities, Smith College, the University of Rochester, and Columbia University. Among other honors, in 1950 President Truman asked her to serve on the newly established National Science Foundation. She did so for the remaining years of her life. This meant much work and frequent trips to meetings in Washington.

Gerty Cori believed that she was very lucky to have had the kind of education provided in Europe and the chance to use it on the opportunities provided in America. These two advantages, she believed, were among the most important reasons for the success of her work. Other advantages that she brought to her work were her personal qualities. She was a woman who always knew the difference between fact and imagination, one of her friends said. Carl Cori agreed. And Carl Cori knew better than anyone else how valuable that quality had been in forty years of companionship and almost as many years of working together in science.

LISE MEITNER
(1878-)

***Austrian-born* physicist *who did important work in solving the problems of* atomic fission**

Lise Meitner's work in science is in physics, a science in which few American women seem to have had much interest. It is often claimed in America that "girls don't do well in mathematics and science." But physics is a science in which some women have shown great ability. Europe has produced two women whose work is considered by the world's most famous physicists to be of the highest quality.

The names of these two women are Marie Curie and Lise Meitner. They helped change completely 19th century ideas about physics. Their names have an important place in any truthful record of the work that resulted in the use of atomic energy and power.

Lise Meitner's work in dividing the atom of the element uranium ended just before success was reached. She had long been working with Otto Hahn when she was forced to leave Germany. Hahn stayed in Germany, and he and Fritz Strassman completed the work. For this work Hahn received the Nobel Prize in 1944. To Lise Meitner came the unusual honor of election to membership in the Swedish Academy of Sciences. Only two other women have been given this honor.

Miss Meitner knew early in her life that she wanted to study mathematics and physics. She was born in Vienna and was one of seven children of a lawyer. She went to high school in Vienna and then to the University of Vienna. As a student she read with great interest about the discovery of radioactivity and Marie Curie's work with the element radium.

At the university she had the good fortune to begin her studies in the theory of physics with Ludwig Boltzmann. At that time many physicists did not accept the theory that all things were made of tiny particles too small to be seen. Professor Boltzmann, however, supported this theory. He believed that the recent discovery of radioactivity had proved that these tiny particles existed. Nevertheless, this theory was still questioned or denied by many European and American scientists.

Professor Boltzmann did not then know that the discovery of radioactivity was soon going to change completely the idea that the atom was the smallest particle in nature. In ancient Greece, Democritus had developed the theory that all things are composed of tiny particles. Because he believed that these particles could not be divided into smaller ones, he named them "atoms," a word meaning "not able to be divided." Nearly twenty-four centuries passed before men began to try to find out by laboratory experiments whether this theory was true. Yet only a few years after the discovery of radioactivity, men were trying to prove by experiments that there were even smaller particles inside the atom. Lise Meitner was starting her work in atomic physics at the very beginning of a promising new time.

In America many years later she talked about the kind of atomic science in her youth. She said that then atoms were generally regarded as solid little things that couldn't be divided. Yet as early as 1868 a Russian chemist named Mendelejeff had made a list of all the known elements, according to their weights. Some scientists noticed that the weight figures appeared in a way that suggested that atoms were made of still smaller particles. Other scientists still did not even believe that atoms existed. Then, while she was still a young student, the discovery of radioactivity led to the discovery that there were at least three different particles inside the atom.

Even before the existence of the particles had been proved, other scientists had suggested that if atoms were attacked in the right way they could be broken into pieces. And so physicists in Europe and America began to try to accomplish what a few physicists had believed was possible.

Doctor Meitner's first step toward becoming one of the important young physicists of her time was to go to Berlin in 1907. She wanted to continue her work in the theory of physics, and the best place to do that was the University of Berlin. Max Planck, one of the world's most famous physicists, was a professor at the university. She also wanted to do experiments and found several opportunities for this. Because she had already done some work in radioactivity in Vienna, she decided to continue that research and to work with a young chemist, Otto Hahn. Hahn was doing research in radioactivity at the Emil Fischer Institute in Berlin.

One thing stood in her way. In those days the Fischer Institute was closed to women. Hahn wanted her to work with him, and he tried to find a way in which it could be done. His own experiments were done in the private laboratory of one of the Institute's officers, and Hahn had no hope that Doctor Meitner could work there. But he had been given an old woodworking room on the first floor where he measured radioactivity. Doctor Meitner was permitted to work there. She was not allowed to enter any of the study rooms on the floor above. And so began the work relationship that Hahn himself said ". . . was to have considerable influence on my scientific development . . ." Doctor Meitner had planned to stay in Berlin for only a short time, but she and Otto Hahn worked together for more than thirty years. And their friendship was to last much longer than that.

For a few years Doctor Meitner's work was limited to what she could do in the old woodworking room without benefit of a laboratory. She measured the rays coming from radioactive materials and studied the physical qualities of these materials. Finally, Doctor Hahn succeeded in getting a laboratory for chemical research on the first floor of the institute. Here the two scientists worked together.

In 1912 the Kaiser Wilhelm Institute for Chemistry was opened as part of the University of Berlin, and Hahn worked there. Doctor Meitner helped Max Planck at the University's Institute for Theoretical Physics. Now their research could continue more easily. Five years later Doctor Meitner was asked to organize a new department of physics at the Kaiser Wilhelm Institute for Chemistry. And only a few years earlier laboratory doors had been closed to her!

She was now in a favored position at a university and in a city where some of the world's best scientific minds were at work. She had the opportunity to know the newest advances in nuclear physics. Her work with Hahn produced results. In 1917 they announced together their discovery of protactinium, a new radioactive element.

Her own work on radiation continued, and during the 1920's she became well known for her work. In 1924 she received the Liebnitz Medal of the Berlin Academy of Sciences, and in 1925 she received the Lieber Prize of the Austrian Academy of Sciences. The next year she became a professor at the University of Berlin. She held this job until Hitler's laws against the Jewish religion made it no longer possible.

However, because she was Austrian, these laws did not at first affect her as much as if she had been a German citizen. After the Germans entered Austria in 1938, the laws against the Jews would apply to her too. Jewish scientists and those who openly opposed these laws began to disappear from German universities after 1934. For a while, though, her work with Hahn continued.

It is important to remember that Hahn and Doctor Meitner did not try to divide the uranium atom so that Hitler or anyone else could make atomic bombs. They were studying radioactive substances because they were scientists interested in changing these substances in the laboratory. Meitner and Hahn had already worked with two other radioactive substances, thorium and radium, and they had discovered and carefully studied another, protactinium. Doctor Meitner had written a book on radioactivity and nuclear physics and was a world authority on that subject. Like Hahn, she was a scientist with a strong desire to learn more and more. And they were two among the little group of laboratory scientists in the middle of the 1930's who were changing one element into another element by methods that changed the atom's nucleus.

To show this change in three simple steps:

1. Every atom contains three particles called protons, electrons, and neutrons. The protons are gathered in the nucleus, which is only a tiny part of the whole atom.

2. The number of protons in an atom of any element is the same as the number that element has in the list of atomic weights.

3. Scientists discovered that it was possible to remove a proton from the atom of some elements. When they did this, the element they were working with was changed into the element next below it on the list. Sometimes the new element changed by itself into something else; sometimes it kept its new form.

To return to the Meitner-Hahn work: such changes were often caused before it was known that the atom contained anything but protons and electrons. When neutrons were discovered in 1932 new methods were possible. In 1934 a group of scientists in Italy led by Enrico Fermi

Date 8-1-87
Acc. No. 3651

attacked atoms of uranium with neutrons. On the list of atomic weights uranium was number 92, the highest element then known. The new substance these scientists obtained did not seem to be like any element then known. Fermi thought it must be a new element, possibly number 93, which had not yet been discovered in nature. Only a small quantity had been produced and it was difficult to be sure. If Fermi were right, it meant that he had added to the number of protons in the atom's nucleus, not taken protons away. This was something new and exciting in the scientific world of that day.

When Hahn and Meitner in Berlin heard about Fermi's experiment they decided to repeat it. They were already familiar with protactinium, which was element number 91. They felt their experience with protactinium would be valuable in studying the substance Fermi had produced.

They began their work, and soon, says Doctor Meitner, "A whole new group of radioactive substances that were not the same as any of the elements below uranium were discovered. Only one answer was possible; they were higher." After a while Fritz Strassman joined them in their work. "Further research," continues Doctor Meitner, "led to the discovery that we were working with an entirely new process."

While they were puzzling over what was happening, the spring of 1938 arrived and Germany took Austria under its control. Lise Meitner's friends helped her to get out of Germany before it was too late, and she went for a while to Copenhagen, Denmark. There her sister's son, Otto Frisch, was working in the laboratory of Niels Bohr. Bohr is sometimes called the father of the atom. He was then, as he would always remain, one of the most respected men in the world of modern science.

In Berlin, Hahn and Strassman continued their work after Meitner left. A few months later they completed the studies that showed that their "entirely new process" was producing barium, element number 56. Hahn was puzzled because the results were against all the facts of nuclear physics known at that time.

Lise Meitner heard about this in Sweden where she had a job at the Physical Institute of the Academy of Sciences in Stockholm. She was not puzzled for long. She knew the work that had been done in Berlin, and she understood Bohr's theory of the atom. She was able to understand the meaning that puzzled Hahn. The appearance of barium indicated that the nucleus of the uranium atom had been divided. If barium (element number 56) had been produced, the gas krypton (element number 36)had also been produced. She saw scientific reasons why this should happen.

She quickly told her idea to Frisch in Copenhagen. He told it to Bohr, who was just leaving for the United States for meetings with scientists there. She and Frisch described the result achieved by Hahn and Strassman for a British scientific magazine. They called the dividing of the atom "atomic fission." They explained that such fission was to be expected in the nucleus of the heaviest atoms. They said that an unbelievably great amount of energy was produced in the fission.

Niels Bohr immediately told this news to scientists at Columbia and Princeton universities in America. Ten days later it was announced at a meeting of American scientists in Washington. Probably no other news had ever caused greater excitement in this group. If the fission of the uranium atom had actually been achieved, the experiment could be repeated in American laboratories. Scientists rushed to begin the experiments. Frisch was already at work in Bohr's laboratory in Copenhagen. He was the first to prove that Doctor Meitner's theory was correct. American laboratories soon produced the same results.

A few years later Doctor Meitner wrote: "It was an unlucky accident that the discovery of atomic fission happened in time of war." Since it did happen at that time it was lucky for America and her friends that Lise Meitner had left Germany. Scientists who stayed in Germany were soon unable or unwilling to talk or write to scientists in other countries. But not all German scientists had remained in Germany and not all Italian scientists had remained in Italy. America and her friends benefitted from the work of scientists who had to leave their countries because of Hitler's laws against the Jews.

Lise Meitner decided to remain in Sweden. Her years there during the war were not happy ones. She was tired and she worried about her friends and loved ones who did not escape from Germany. Those days passed, and better ones came.

After the war was over, she came to America for a visit. She stayed a year and returned to Sweden to become a Swedish citizen. At the University of Stockholm she has been able to continue her work in atomic research. Many honors came to her. Sweden made her the only living woman member of its Academy of Sciences. Germany and Austria also honored her. In 1947 the City of Vienna's Prize in Sciences was given to her, and in 1949 she received the Max Planck Medal. Four American colleges—Syracuse University, Rutgers University, Smith College and Adelphi College—have made her an honorary doctor of science.

HELEN SAWYER HOGG
(1905-   )

An astronomer whose work has earned for her high honors and fame among scientists.

Helen Sawyer did not know that she would ever want to be an astronomer until she was in her third year of college. She began to study astronomy that year. She became so interested in the stars that she decided to make astronomy her major study in college. She has never been sorry. The stars have been her lifelong work. By the time she was forty-five she had been a wife, a mother of three children, and a widow. And she had already been honored with the important Annie Jump Cannon Prize in Astronomy. Since then she has won increasing fame among astronomers.

As a child, Helen Sawyer learned about the stars from her mother. In the winter at Lowell, Massachusetts, and in the summer at Lake Winnepesaukee in New Hampshire, Mrs. Sawyer pointed out the stars to her. She told Helen all she knew about them. Mrs. Sawyer also collected rocks and flowers, and she often read poems about nature to her daughter. Helen herself made a collection of unusual plants during several summer vacations at a cousin's farm in Vermont.

Helen's father was a wealthy businessman. When she was about five years old her sister married, and Helen was the only child in the home. Her father died when she was twelve years old. After his death, Helen continued to attend the public schools in Lowell. One of the city's best school teachers lived in her home for many years. She had a very strong influence on Helen's development. Respect for education surrounded this child all her young life. Summers at the lake continued to be happy vacation months each year. School days were happy days, too, even though there was much work to do. Helen liked all her studies, and she was one of the best students who finished Lowell High School in the spring of 1921.

She was now prepared for college. Money for college was available, and she decided to go to Mount Holyoke College. But she was young. She was not yet sixteen years old. Perhaps it would be better not to leave home for one more year. She went back to Lowell High School for a fifth year of work. When she left for college the next September, "Mount Holyoke seemed halfway around the world to me." Thirty-six years later she flew to Russia, but the 70-mile distance between Lowell and Mount Holyoke in South Hadley, Massachusetts, seemed almost as great that day.

That September day in 1922 she did not know that in only a few years she would be helping to measure the distances between stars. Nor did she know that in only four years she would be helping Doctor Harlow Shapley, the director of the Harvard Observatory. Astronomy was far from her mind when she began her trip to college. In her first year she studied chemistry and decided that it would be her principal subject. She was quite happy about her choice until she met Doctor Anne Sewell Young. Life has never been the same for Helen Sawyer since that meeting.

Mount Holyoke had a very good astronomy department. It was headed by Doctor Young. The stars were the most important thing in her life, and she made her students feel her excitement. Helen Sawyer was still a young girl when she began to study with Doctor Young.

She felt the excitement in the classroom and in the observatory. The excellent telescope gave her a much better view of the stars than she had had as a child in Lowell.

In January that year the sun was due for a total eclipse. This is a very important event to astronomers. Some astronomers travel halfway around the world to get the best view of a total eclipse. Doctor Young surprised the college authorities by making arrangements for a special train to take all the students of the college to central Connecticut. There they would get the best view of the eclipse. The train stopped that cold January morning in the middle of an empty field covered with snow. The students and some of the braver professors stood knee-deep in the snow. Not a single branch of a tree spoiled their view of one of nature's most magnificent sights—a total eclipse of the sun on a clear day.

Those Mount Holyoke women still enjoy the memory of that eclipse. They also enjoy remembering that no one got sick from the cold weather that day. Although, "I don't believe I ever knew what it meant to be cold before that morning," Doctor Hogg says.

During her fourth year at college another very important event occurred. Doctor Annie Jump Cannon visited Mount Holyoke and learned about the work of some of the young students in astronomy. Doctor Cannon was an astronomer at Harvard University, where she did very important work. As a result of her visit, arrangements were made to give Miss Sawyer a scholarship for a year at Radcliffe, a college for women near Harvard. There she could continue to study astronomy.

While at Mount Holyoke, Helen Sawyer had become interested in groups of stars known as globular star clusters. This was one of Doctor Harlow Shapley's special interests, too. So when Miss Sawyer went to Radcliffe she began to work with the director of the Harvard Observatory. The results of some of their work that first year were published in a Harvard scientific magazine. They were signed by Helen Sawyer and Harlow Shapley, in that order!

A report in that same magazine was signed by a Harvard student from Canada, Frank S. Hogg. He had come to Harvard to study astronomy too. Soon Helen Sawyer and Frank Hogg met. They found that they shared many interests—personal and scientific. Soon they were in love, but marriage had to wait a while. When Frank had finished his studies at Harvard, he went to England for a year. Miss Sawyer remained at Radcliffe to continue her work on globular star clusters. They married when Doctor Hogg returned to work at Amherst College for a year. Mrs. Hogg taught astronomy at Mount Holyoke and completed her work at Radcliffe.

She had done so much work on globular star clusters that the name Sawyer was already well known. For that reason Doctor Helen Sawyer Hogg's scientific work in this subject is always signed with the name Sawyer. For all other purposes she uses the name Hogg.

In the autumn of 1931 the two Doctor Hoggs went to British Columbia, in Canada. Frank Hogg had been given a job at the observatory in the city of Victoria. No job was available for his wife. But she was allowed to use the observatory's telescope for a few nights each year. An eventful three years followed. A daughter, Sally, was born, and caring for her took much of her mother's time. Children, however, were welcomed by the Hoggs. Their interest in the stars did not lessen their need for a full life that included home and community responsibilities. Two sons followed Sally later. The children were a great comfort to their mother when Frank Hogg died at the age of forty-six.

In the autumn of 1931 Doctor Hogg, with the help of her husband and others at the observatory, began research in globular star clusters. She took pictures of eight globular star clusters that could be seen in Victoria's night skies.

To explain a little about globular star clusters and why astronomers are interested in them: More than one hundred globular star clusters are known today. Some of them contain a few thousand stars. Others have a hundred thousand or more. Some of these stars become bright and then pale at regular periods. They are called variable stars. They are especially important to astronomers, who use them to find out how far objects in space are from the earth. Astronomers measure distances by a process based on the amount of light a variable star gives off at its brightest and palest moments and on the length of time between these moments. Therefore the discovery of variable stars and measuring them are very important tasks.

To do this an astronomer must be able to take good pictures of the stars. Then the astronomer must study these pictures and compare them with other pictures. An understanding of mathematics is needed for this work.

In the three years the Hoggs were at the observatory, Doctor Hogg took from 350 to 400 pictures of globular star clusters. In the cluster known as Messier 2 she found six new variable stars. In five of the other clusters she studied she found 132 new variable stars. This was a ten per cent increase over the variable stars that had been known before. In four of these clusters, no variable stars at all had been known.

The results of this first research program were valuable to astronomers. To one who knows little about an astronomer's methods, it is interesting to see how this work is done. So imagine Doctor Hogg sitting on a movable floor that has been raised up to the top of the observatory. Her eye is held next to the camera at the end of the telescope. Her fingers slowly move to keep the telescope pointed at the cluster as her eye watches its motion in space.

Sometimes the pictures were taken in one or two minutes. Sometimes twenty-five to thirty minutes were needed. Later she took pictures that required sixty minutes. Her eye had to be held against the camera for the whole time.

This kind of work has to be done during the few months of the year when the stars are in their best position and the nights are clear enough for good results. One summer young Sally had to be cared for while her mother was doing this work. Her parents carried her to the observatory in a comfortable basket. There she slept while her father helped her mother. Between pictures her mother came down from her high seat at the top of the observatory. She fed Sally and took care of her other needs. Then Sally was put back in her basket and her mother returned to the top of the observatory. One night a famous astronomer visited the observatory and was surprised to hear a baby crying. "Oh, that's the Hogg baby," its parents heard the observatory director explain.

When the new David Dunlap Observatory at the University of Toronto was nearly completed, Doctor Frank Hogg was offered a job in the university's department of astronomy, and his wife was given a job at the observatory. It was her first job with a salary. The name Sawyer was becoming increasingly well known for her work on variable stars in globular star clusters. Frank Hogg was also becoming well known for his work and his early death was truly a sad event. At the age of forty-one he became director of the observatory; at forty-six he was dead.

But when the Hoggs came to the University of Toronto, seventeen years of working and living together were ahead of them. By the autumn of 1937 their two sons had been born. The next year she advanced to the position of Research Associate at the observatory. This was the beginning of her rise to a professorship at the university in 1957. This was an unusual honor for a woman scientist at that university.

All of Helen Sawyer's studies of globular star clusters had been done with telescopes in the northern United States or in southern Canada. But some globular star clusters can be seen best in southern skies, and she wanted to take pictures of these. In 1939 money was granted for this purpose, and the University of Arizona offered to let her use its observatory.

Just before beginning this work she had completed a list of 1116 variable stars in globular star clusters. This valuable research was published in 1939 and was greatly welcomed by astronomers. Lists of stars are of great importance in astronomy. No complete list of variable stars in globular clusters had ever been published before. Now astronomers could know exactly what work had been done on all known variable stars in globular clusters. More than half of the variable stars in the list had been discovered before Helen Sawyer was born. The first one had been found in 1860. Of the 500 to 600 discovered since her birth, she had discovered 142.

Seeing southern skies through a telescope was a new experience to Doctor Hogg. In the summer of 1939 she began work on a series of 279 pictures at the University of Arizona. By this time she knew how difficult this work was. Examining the pictures takes a very long time and requires close attention. Hundreds of stars may be searched before one variable is discovered. And often, just when the work is going well, the moonlight becomes too bright to see the stars.

Nevertheless, Helen Sawyer was devoted to the study of variable stars. Much of her time in the 1940's was spent studying them. She continued to teach at the University of Toronto and took new pictures with its observatory's telescope. She also continued to share with her husband the many human responsibilities and pleasures of her home and community. One year she taught astronomy at Mount Holyoke so that the director of its observatory could go to South America to see an eclipse. It was hard work to teach at Mount Holyoke and go to Toronto as often as possible. But, "Doctor Farnsworth might not have been able to see that eclipse if I had not helped," Doctor Hogg says. Eclipses are very important to astronomers. Someone who has stood knee-deep in snow to see an eclipse was not likely to forget it.

Reports by Helen Sawyer appeared in Canadian, American, and, sometimes, foreign scientific magazines. Usually they told about new variable stars that she had discovered or new facts about other variable stars. In 1947 she published a book which gave astronomers information on where they could find all that had been written about this subject. Sometimes she was able to correct errors that other astronomers had made. In 1950 she was given the Annie Jump Cannon Prize for her work in astronomy. Four years earlier her work had won her election to the Royal Society of Canada, the only woman in the field of physical science ever so honored.

Always more work seemed to lie ahead than had already been done. As telescopes became better, new globular clusters were found. But that was not the only discovery. Evidence began to appear that new stars were being created! The old theory that all the stars had been created at the same time was no longer believed. The process of creation was still continuing.

This was a very great change in the theory of astronomy. Helen Sawyer's thoughts changed too. She was not like the man who refused to look through a telescope because he was afraid he would believe what he saw there. Hers was the faith of the astronomer who said, "The astronomer without faith is mad."

All of her faith was necessary on the first morning of the new year of 1951. The three children were waiting for their father to come to breakfast. When she went to waken him, she found him dead.

After that, the years were busier than ever. The university raised her rank and her salary. She began to take on her husband's responsibilities outside the university.

And she continued to write for the Royal Astronomical Society of Canada. Sally went to college, and the boys finished high school and began their college education, one in astronomy and the other in chemistry. Helen Sawyer continued to take pictures of the stars. In 1955 she published a new list of variable stars in globular star clusters. It contained 329 new ones. And 99 of these had been discovered by Helen Sawyer.

Many honors have been given to her. The National Science Foundation asked her to direct its program in Astronomy in 1955. She is the only woman who has ever held that position. The Royal Astronomical Society of Canada elected her its president in 1957. Mount Holyoke awarded her an honorary degree in science in 1958. In August 1958 she visited the Soviet Union as the guest of the Soviet Academy of Sciences in Moscow.

Helen Hogg still finds time for her writing. Every week she writes about the stars for a Toronto newspaper. She finds time for her sons' and daughter's children. She is a woman of science who has combined the art of homemaking with scientific work outside the home. Hers has been a life full of responsibilities. They have brought her a human understanding that does not come merely with increasing age and mental activity. It comes only when body, mind, and heart—or spirit—move along together.

ELIZABETH SHULL RUSSELL
(1913-)

A scientist whose studies are helping to show how genes produce their effects

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Genetics is the scientific study of how parents pass their physical qualities on to their children. One wonders if Elizabeth Shull's parents passed on to her the qualities that made her a geneticist. Five of the six farm-boy brothers in her father's family became scientists. Her father was a geneticist. Her mother taught zoology for several years before she married Doctor Shull. Of their two children, Elizabeth became a geneticist and her brother became a physicist, like his mother's brother.

Yet the geneticist knows that the conditions in which we live also help to determine what we become. In Elizabeth Shull's early life, conditions turned her more to the study of plants than to the study of animals.

As a schoolgirl of ten or eleven, she was interested in both plants and animals. One summer vacation she spent hours making a study of all the flowering plants in a forest near her home. She collected the plants and preserved them with her mother's help. When she finished, she had a plant collection that was good enough to be used in her high-school biology studies.

Elizabeth was a year or two younger than most students. Except for this her high school life was similar to that of many other girls in high-standard American high schools. She was born in Ann Arbor, Michigan, where her father was a professor of zoology at the University of Michigan. The university had a high school for the children of professors. Here she was lucky to have instruction from a man who taught students a method of learning. He taught his biology students the scientific approach to a subject. Thus when she was still in high school, Elizabeth Shull learned one of the most important processes of the scientific method. That is, state a theory and then prove it right or wrong. This method is very different from the right-or-wrong, true-or-false guessing games in which students guess the answers without learning how to think reasonably. In such guessing games, students often have a good chance of being right no matter how little they know about a subject.

When she was sixteen Elizabeth Shull was ready for college. She had decided to become a high-school biology teacher. Summer vacations had kept alive her interest in both plants and animals. One event had occurred in high school that may have added to her increasing interest in zoology.

For one of her biology experiments she gathered the film of matter that floats on the surface of ponds. This film, she knew, contained both tiny plants and animals. She added rice and rice water to the film for a month until it was rich in Paramecia–small animals that reproduce themselves by dividing in half. Hour after hour she watched these tiny animals through her microscope. Finally came the excitement of seeing one of them divide. What had been one living animal became two living animals. It was a rewarding experience for a schoolgirl. She never forgot it.

Whether or not this experience was of much influence, she decided to study zoology and general science at the University of Michigan. She also studied chemistry and mathematics. She liked all her studies and she did well in them. During two summer vacations she taught nature study at a children's camp. During two other summers she studied animals at the University. This work showed her how interesting animals could be. They did so many more things than plants. And there were so many different kinds of animals.

She still planned to teach biology after she finished her work at the University in 1933. At her father's suggestion she decided to study zoology at Columbia University for a year. During that year something happened that often happens earlier in a science student's life—the "something" that makes a young person decide the subject in which he wants to work.

At Columbia University, Miss Shull had her first work in the theory of genetics. At the University of Michigan she had studied the kinds of things genes can do in passing on the physical qualities of the parents to the children. She had found this subject interesting, but not any more so than other subjects. At Columbia her attention was directed to the processes by which genes produce their effects in the life time of a single animal.

Let us describe what happened to her in her own words: "I read some studies by Sewell Wright of the University of Chicago telling about work he had done with genes. He tried to find out the processes used by certain genes in producing certain qualities. This held my interest as nothing had quite held it before. Almost without my knowing it, something happened to me. I knew that I wanted to be a geneticist, and I decided to go to Chicago."

For the next three years she studied and worked in Doctor Wright's department at the University of Chicago. This experience gave direction to her life. Doctor Wright had been studying the color of little animals called guinea pigs, trying to discover how genes produced the colors in the animals' hair. All these colors—black, brown, red, yellow, and white—were produced under the influence of certain genes. He was trying to discover how the genes did their colorful work.

Guinea pigs lose their hair all the time and grow new hair, but the color markings always remain the same. If skin is exchanged between black and white regions of a spotted guinea pig, the skin from the black region continues to produce black hair, and the white region produces white hair. This happens even when the surrounding hair is the other color. All this was known to happen. But the processes by which it happened were still a mystery.

It was a mystery that was soon interesting Elizabeth Shull. She began to make actual measurements of the effects of certain genes on the color of guinea pig hair. She had to separate from the hair the substance that produces color. Then she compared the amounts of this substance present in different colored hairs.

While this lengthy study was going on, Elizabeth Shull married another zoologist-geneticist student. He completed his work at the university a few months before Elizabeth and went to Bar Harbor, Maine, to become a research scientist at the Roscoe B. Jackson Laboratory there. This was a new laboratory and it had little money. It could not offer a salary to a second Doctor Russell, but Elizabeth Shull Russell was allowed to use the laboratory.

Shortly after her arrival at the Jackson Laboratory, Elizabeth Russell began a study of the genetics of tumors, or growths that are not normal, in the fruit fly. Much of man's understanding of genetics has come from the study of this insect. Elizabeth Russell decided to study the kind of tumor that results from too much color-producing substance.

She proved certain theories about these tumors and discovered the location of some of the genes that influenced the appearance of the tumors in the fruit fly.

By the time these studies were completed, she had become interested in the hair color of mice. But another important job interrupted her research. She had three sons and a daughter between 1940 and 1946. She had very little time to spend in a laboratory. After the birth of her fourth and last child, she completed in 1947 a study of the coloring substances in 36 different kinds of mice. In this study she was able to obtain a quite exact idea of the effects of certain genes on the coloring processes.

Then came two serious troubles, one after the other—she was left with four small children to care for, and a fire destroyed the Jackson Laboratory. All that remained of the laboratory were the records that the scientists had at home on that terrible day in October, 1947.

The most serious laboratory loss was its animals. None of the mice survived; 90,000 of them were killed. This was a serious loss to hundreds of other laboratories where these animals were being used in medical research. Mice are similar to humans in many ways and this fact makes them of great value as research animals. Also, they are affected by many of the same diseases that humans are. They pass on to their children a weakness for certain diseases, just as humans do. The Jackson Laboratory had been developing mice that were certain to get particular diseases. Scientists in many parts of the world were depending on the Jackson Laboratory to provide them with mice exactly like earlier mice for use in research. And suddenly, in a few hours, all these carefully raised mice were gone. The loss was felt all over the world.

Elizabeth Russell was given the responsibility for rebuilding this part of the Jackson Laboratory work. Research centers in all parts of the world began to send back mice with their proper records so that the Jackson Laboratory could begin its work again.

Mice give birth early and often. Females often have babies eight times by the time they are one year old. But, it was more than a year before the Jackson Laboratory had any mice for research purposes. Nevertheless, by 1950 there were more mice than before the fire.

The following facts give some idea of the size of her job: In 1957 3,000 mice were being born at the laboratory every day and detailed records were kept for each one. There were 67 different kinds of mice, and the mice in each group were exactly alike. Each week 7,500 mice left the laboratory—some 400,000 in a year. They went to 600 laboratories in 22 countries—from Kenya in Africa to Korea in Asia, and from southern Argentina to northern Europe. The number of mice at the Bar Harbor laboratory was about 1,000,000, and the demand for the animals was so great that plans were being made to double production.

But all that was separate from Doctor Russell's work as a geneticist. As soon as the new building was ready, she began new studies to reveal how genes accomplish their effects. New studies of coloring were made. The skin from unborn mice was transplanted to newborn mice of a different hair color. It was shown that certain color-producing "devices" work in the little hole from which the hair grows.

Certain genes that affect the color of hair also have severe effects on the blood. Therefore Doctor Russell's attention turned to a study of blood disease. She transplanted blood-forming substances from normal mice to mice that had a blood disease. The results showed that the genes that produce blood disease have a direct effect on the blood-forming substances in the body. In another study she discovered important facts that help to explain why some animals are not able to reproduce.

However, some of her most interesting work is in muscular dystrophy, a disease of the muscles that makes them useless.

In the summer of 1951, she noticed one of the young mice was dragging its foot. "Funnyfoot," she called it. Geneticists are always looking for animals that are different from the others. A gene may sometimes copy itself incorrectly and produce an animal with a different gene. The new gene is passed on to the animal's children, and they too are different. When this happens geneticists try to find out all they can about such animals.

When Funnyfoot appeared that summer, Doctor Russell asked a student, Ann Michelson, to study Funnyfoot. Soon other baby mice were born with this same foot problem. The parent mice were passing it on to their children. Under Doctor Russell's guidance Miss Michelson made many tests of these mice. She found that Funnyfoot had a muscle disease similar to the muscular dystrophy which affects humans.

As soon as this similarity was known, scientists studying muscular dystrophy wanted some of these mice for research. But only a few were born, and many of these died after a few months. Also, they were not able to have babies. This supply problem was answered by transplanting reproduction parts from Funnyfoot females into normal female mice. The normal mice then produced a large supply of Funnyfoot children. These mice are now being used in medical research centers. It is hoped that they will increase our understanding of muscular dystrophy and help find a cure for it.

In addition to her responsibilities in obtaining a supply of these mice, Doctor Russell wanted to find out how the genes passed on the disease. Studies at the Jackson Laboratory in which she has had a big part indicate that muscular dystrophy is passed on to children by action of a single pair of genes.

In 1954 Doctor Russell organized a meeting of two hundred scientists interested in genetics. Many of them presented reports of their studies, which she later helped to publish. This meeting increased her feeling that all the known facts about genetics of humans and other warm-blooded animals ought to be brought together and published. In September 1958 she was able to begin work on this.

This kind of work is valuable because it enables a scientist to become familiar with the work, ideas, and methods in other laboratories. And it is helpful in planning future researches. When Doctor Russell's work is completed, it will also be useful for her own personal purposes and for teaching students at Jackson Laboratory. But it will probably have other uses too. Doctor Russell believes that methods used in the study of genetics can be very helpful in finding answers to human medical problems.

At this point in her life Elizabeth Russell seems to be only halfway in her work as a geneticist. She has the possibility of nearly a quarter of a century of active life ahead of her. Her name is known and her work respected by older leaders in genetics, and she is often asked to speak at meetings. She is a member of the American Academy of Arts and Sciences, one of the very few woman scientists to whom this honor has been given.

When asked how much her choice of work was due to her genes, she says, "Let us not forget that any child in a home where parents are scientists learns before he is able to read that science is a very interesting subject. That must have a lot to do with his choice."

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RACHEL FULLER BROWN
(1898-)

***Discoverer, with Elizabeth L. Hazen, of a valuable* antibiotic**

When Rachel Brown looks back over her life, it always seems a surprise that she ever went to college. Her family had little money that could be used for education. Early in life her mother was left with two children to support, and it soon became apparent that she would not be able to supply the money for Rachel and her younger brother to go to college. Nevertheless, Mrs. Brown wanted her children to have a good education. By the time her daughter finished high school she was aiding, as well as she could, Rachel's efforts to get a loan, a scholarship, part-time work—anything that would enable her to go to Mount Holyoke College. Rachel had done so well in high school that a scholarship was given to her. Then, a wealthy friend of her grandmother offered to pay for the girl's college education. She was so generous that Rachel had everything a Mount Holyoke student of her day could desire—far more than many of her fellow students.

It now seems strange and wonderful to Doctor Brown that someone should have chosen her to receive this gift. But the fact that she herself is now even more generous seems even more surprising. "I never dreamed that I would ever be in such a position," she says. It is easy to see why this is true. The scientist who works in government service does not expect to become rich. It seems as if wealth was so unimportant to Doctor Brown that when the opportunity for it knocked on her door, she had no interest in opening the door and saying, "Come in."

Rachel Brown says, "If you have enough, why should you want more?" Knowing exactly what she was doing, and probably against the advice of many friends, she did not accept any of the money earned by the antibiotic which she helped to discover. Its other discoverer, Elizabeth Hazen, did the same. But they made sure that their share would be used for the advancement of science.

The story of Rachel Brown is an American success story. It reveals qualities in human beings that ought to make us hopeful about the future of the human race. She liked all her studies and did not prefer one more than any other. She did not study chemistry or physics. But she did have both fun and interest in performing some chemistry experiments at home. When she went to Mount Holyoke, she chose history as her major study.

Before very long, however, something began to happen that caused her to change her mind a little. She became aware that chemistry, quite as much as history, was catching hold of her interest. "I liked it, though even today I can't be sure why, unless it was because of its ordered pattern and exactness."

Mount Holyoke had (as it has today) an excellent chemistry department. It was headed by an excellent teacher, Doctor Emma Carr. Under her influence, Rachel Brown decided to study chemistry and history. After she finished her work at Mount Holyoke in 1920, Doctor Carr urged her to go to the University of Chicago, for further study. Once more the friend of her grandmother provided the money for a year of study. But Miss Brown helped herself this time, too. She worked in a laboratory while studying at Chicago.

Like many young women of that time, she had been preparing to teach. When she completed her year of study at Chicago she found a job at a school for girls near Chicago. But she soon discovered she did not want to make a lifework out of this kind of teaching and living. After three years she returned to the university with enough money, she hoped, for the two years of work necessary for her **Ph.D.** in chemistry. Though her grandmother's friend would gladly have helped here too, Miss Brown preferred to do it by herself.

At this time she met a very real problem. Two years were not very long for all the work necessary for her Ph.D. Actually, she was asked to do more work than usual for a Ph.D. in chemistry. She had also chosen to study **bacteriology**, which required very much work. She worked very hard in those two years and seemed, at their end, to have completed all the requirements. Only acceptance of her thesis, a written report of her studies, and then the difficult orals, or spoken tests, remained. For some reason still unknown to her, acceptance of the thesis was delayed, and the orals could not be given until the thesis was accepted.

While she waited anxiously for her professor to decide about her thesis, she used up all her money. Soon she would have to take care of her mother and grandmother. Then she received an offer of a job as a chemist in the New York State Department of Health in Albany, New York. The job did not depend upon whether she had her Ph.D. With these necessities facing her, she left Chicago. And that, for the moment, had to be the end of her Ph.D.

Seven years later she was in Chicago to attend a meeting of scientists. The professor who had delayed acceptance of her thesis suggested to her that she stay in Chicago for a week and take the tests. She stayed and took the tests, the earlier thesis was accepted, and she received her Ph.D. seven years after she had expected it.

The work that she had been doing at Albany was in the chemistry of microorganisms. These are tiny plants and animals, so small that a microscope is needed to see them. Scientific work at the Health Department Laboratory included the normal services required of such laboratories. Two of these were: tests of substances sent by doctors to aid them in recognizing disease; and making serums and other medicines for fighting diseases. In those days pneumonia, a disease of the breathing-parts of the body, was a serious disease that killed many people. It was often treated with good success with serums. Many different serums were needed because there were several different kinds of bacteria (pneumococci) that caused pneumonia. A serum that worked very well for one kind might have no effect on another kind. Doctors needed to know what kind of pneumonia each person had and be able to get a serum that worked against it.

Doctor Brown's work was to remove a particular substance from each kind of pneumococcus so that it could be used in making the pneumonia serum. Much of her published work during her first fifteen years at Albany described the chemistry of pneumococci. To explain a little about the work she was doing:

For any kind of pneumococcus being studied, horses or rabbits were given that kind of bacteria. After a period of time blood was taken from these animals and serum made from it. When this serum was given to human beings suffering from the same kind of pneumonia as the animal, the serum fought the pneumococci that were threatening the person's life. Doctor Brown's job was to find answers to some of the many problems of making the different kinds of serum.

The aim of all this work was to enable any doctor to recognize a disease quickly and then to have the right serum ready quickly. When an antibiotic was discovered that worked well against most (though not all) kinds of pneumonia, pneumonia serums became less important. But this did not happen until the 1940's—after Doctor Brown had been at the Albany laboratory for fifteen years.

Her work was not limited to pneumococci. Some of her laboratory's other problems in the chemistry of other microorganisms came to her too. But she was also given great freedom to work on problems of her own choice. It was this freedom of choice that was to bring the greatest benefits to human beings. With them came greater opportunity for other scientists to work on problems of their own choice, too.

It was natural enough that a scientist of Doctor Brown's experience should become interested in antibiotics. Her field was the chemistry of microorganisms, and antibiotics are chemical substances obtained from microorganisms. One antibiotic, penicillin (1941), had done wonderful things, and another, streptomycin (1944), was also valuable. Two others, chloromycetin and aureomycin, soon followed, each of them bringing relief to human beings from more and more diseases. However, as antibiotics became more widely used, unpleasant results often accompanied the wonderful cures. These results were so uncomfortable that sick people sometimes said that the cure was worse than the disease.

One result was a painfully sore mouth. This is caused by a rapid growth of fungi inside the mouth. Some bacteria in our bodies control the growth of fungi. Antibiotics killed many kinds of bacteria but did not kill fungi. They often killed the bacteria that fought the fungi, which then had a good opportunity to grow.

This is only one of numerous examples of how fungi can cause illness. Many examples became common after antibiotics were used in large amounts. Therefore some research scientists began to search for an antibiotic that would be antifungal: that would fight fungi as other antibiotics were fighting bacteria. The antifungal substance would have to be safe for human beings, too.

In the late 1940's Doctor Brown and Doctor Hazen decided to join the search for an antifungal antibiotic. Doctor Hazen had already made studies of the actinomycetes, which are microorganisms found in certain soils from which several antibiotics have been obtained. She gathered many small amounts of soil from possible sources, removed the actinomycetes, and tested them to see if any of them would destroy the fungi that made people ill. She found a number of microorganisms that seemed to work. But the task of removing the antibiotic from these microorganisms and learning if it could benefit human beings required a biochemist like Elizabeth Hazen.

Working together the two doctors began the search for an antifungal antibiotic. Soil from a farm in Virginia yielded the most promising actinomycete. Tests showed that it was not only antifungal but also that it was different from any other known actinomycete. After Doctor Hazen had removed the actinomycete, the next step would be to see if Doctor Brown could remove the antibiotic from the actinomycete. At this point they knew an antifungal antibiotic was present, but that was not enough. It is not uncommon for an antibiotic to have no worth because it loses its abilities when being processed. Also some antifungal substances are too harmful for human use.

The method that Doctor Brown used to remove the antibiotic began by making a kind of souplike mixture, or broth, to grow the actinomycete in. After four or five days the growth (called the pellicle) on the surface of the broth was removed. Tests were made which revealed not one but two antifungal substances. One was in the broth and one in the pellicle. Doctor Brown studied the two substances to learn how they were different. They decided to continue working with the one found in the pellicle. The problem of removing the antifungal substance was not simple, even for a trained biochemist. In the end Doctor Brown obtained a fine yellow powder. They called this substance "fungicidin" and began to test it in mice.

By the early autumn of 1950, Doctor Hazen and Doctor Brown announced that they had successfully produced two antifungal substances from a soil actinomycete. One of the substances was different from all other antibiotics that they knew about. In tests it had worked well against many fungi and showed little activity against some of the bacteria attacked by other antibiotics. Tests in the laboratory on harmful fungi had been very promising, they said. Further studies into its usefulness for human beings were needed. And these studies would have to be made by persons with medical training.

That announcement brought immediate offers from manufacturers of antibiotics. They offered to make the product—or to produce it—for antibiotics are obtained from plants grown in huge tanks. It looked as if two government-service scientists had a product that might have a high market value. Each of them knew she did not want to make money for her own use out of their discovery. Since help from industry was needed for further research, testing, producing, and marketing, they asked an organization called the Research Corporation for help.

In a short time this organization was managing the money problems connected with what proved to be the first safe antifungal antibiotic. By this time its discoverers had decided upon a name for it—nystatin. Its first letters honored New York State, in whose laboratories the work had been done. A permit to make nystatin was issued by the Research Corporation to E. R. Squibb and Sons. Production soon began in this manufacturer's laboratories. As quickly as was safely possible, doctors began to use it on sick people.

Not only did it work well against a number of diseases due to fungi, but nystatin was especially safe for human beings. Given alone, or together with other antibiotics, it prevented or cured many conditions from which people had been suffering.

Some idea of its widespread usefulness may be gained from figures published by the Research Corporation in 1957. For the privilege of making nystatin the manufacturer had to give the Research Corporation a small part of the earnings from the sale of the product. In 1957 the Research Corporation announced that it had given away $135,000 of this money. This figure indicated it would probably be only a few years until the first million dollars had been given away.

By agreement between the Research Corporation and nystatin's discoverers, all the money was to be used to aid research in the natural sciences. Special attention is given to providing advanced scientific training for scientists at the New York State laboratories. Already Doctor Brown has had the pleasant experience of having some of nystatin's money used by people whose problems and abilities she knows well. But all this has made no noticeable change in her life. Her work at the laboratory continues much as usual, with special interest on research problems.

Her life outside the laboratory also continues as usual. One of the things she did as soon as she was able, after becoming responsible for her mother and grandmother, was to buy a home. She did this together with a friend. The home was big enough for the four of them and there was a garden outside for growing flowers. It was a totally adult arrangement, and seemed likely to continue so. But her church had young members who needed Sunday-school teachers and she became one. Thus she met many young people, and now she is treated like a member of their families. She has quite a large family, and it keeps growing. For the last few years she has been teaching ten-year-olds, an age group she enjoys.

After the death of her grandmother there was an empty bedroom. At this moment a young doctor from China needed a home while she worked at the laboratory for a few months. The experience of sharing her home with a young Chinese woman was so rewarding that Doctor Brown considered herself lucky when a second Chinese woman came just as the first was leaving. Each young

Gerty Theresa Cori with her husband Carl in their laborat

Science Service

Lise Meitner with a group of science students

Ken Bell

Helen Sawyer Hogg looking through the instrument with which she has found many new variable stars

Elizabeth Shull Russell in her laboratory

Rachel Fuller Brown (right) studying records with Dr. Elizabeth L. Hazen

Courtesy of Westinghouse

Chien Shiung Wu with a group of scientists and science students

Trude Fleischmann

Edith Hinkley Quimby in her laboratory

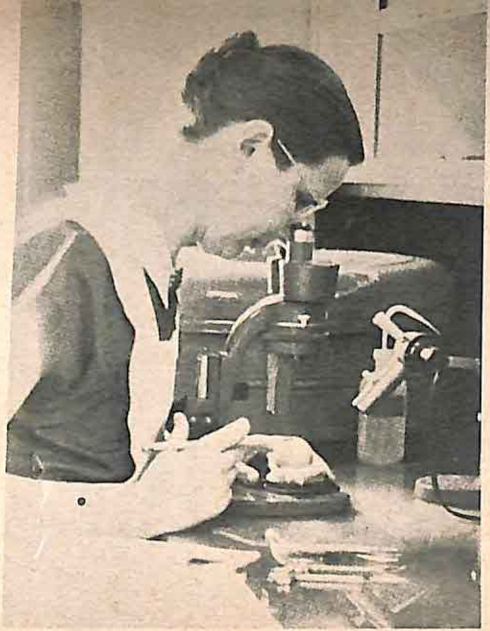
Official United States Navy Photograph

Florence van Straten working with instruments to study weather

Jocelyn Crane ready to dig
for sea animals in West Africa

U.C.L.A. Photographic Department

Gladys Anderson Emerson with her dog Chemie



Dorothea Rudnick ready to work on an egg in her laboratory

Printed in U.S.A.

woman had friends and family studying in America, and the Brown home was open to all of them. Since about 1946 it has been filled with Chinese students who return to it several times a year just as American students go to their own homes for college vacations.

Spring vacation not long ago found seven visiting Chinese at the house in Albany. "I just loved having them—I always do," said Rachel Brown. She especially enjoys the children who have been born to members of the group. A gate at the top of the stairs and a toy horse in front of the fireplace are now part of her usual furniture.

To know Rachel Brown is to know that science is a field in which human beings may, if they want to, develop standards and values that are not measured by money. Nor need the development of these standards prevent a scientist from receiving fame and honor. She has received scientific fame and honor, but this warm and humble woman of science is most satisfied by knowing that her work has helped to save lives and end human suffering.

CHIEN SHIUNG WU
(1915-)

Nuclear physicist whose work helped to prove that a theory that had been accepted for a long time was wrong

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One of the most famous women of science in America today is a Chinese woman, Doctor Chien Shiung Wu, professor of physics at Columbia University. In the physical sciences, Doctor Wu is among the greatest women in the world today. When Princeton University, in the spring of 1958, gave her the first honorary Ph.D. in science that it had ever given to a woman, its president declared that she had "earned the right to be called world's most important female experimental physicist."

The quality of her scientific work has brought her the rank of professor, a rank rarely given to women in the best American nuclear physics centers today. But Doctor Wu does not look like a professor. She is very small and she dresses in Chinese clothing. It is a form of clothing which, whether or not it is hidden beneath the laboratory coat of a research scientist, shows her strong and lasting ties to the land where she was born. She is a true daughter of her people.

Yet in the surprising strength of her handshake is a warmth that goes beyond race or nation. That handshake becomes a request for the untrained person to try to approach her science with a completely open mind. If he can do this, he may find a bridge of understanding is possible between his mind and the nuclear scientist whose work he usually makes no great effort to understand.

It is not easy for an adult to take first steps toward what he does not understand. Young people do this more easily. Yet for people of any age whose minds are not closed, for those who have not forgotten how to use their imaginations, it is possible to take first steps toward understanding.

In high school chemistry experiments, two gases that cannot be seen are united to become water, which can be seen. That kind of experience makes our imaginations work, as we look at a glass of water and try to understand that both the glass and the water are built of materials that cannot be seen. But these materials have somehow combined and have become possible to see. When we try to understand that the glass, and the water, are made of atoms, imagination has helped us take a first step in atomic physics.

It is not hard for the person who has taken his first leap into the dark successfully to take a second step, which leads him into Doctor Wu's field of nuclear physics. This is the physics of the nucleus, or center, of the atom. This step happens when our minds try to understand that each atom is made of smaller particles—of protons and electrons, of neutrons, of particles called mesons, and of K-mesons, which were discovered as recently as 1952-53, and which **decay** into two or three particles called pi-mesons.

As a child in China, Chien Shiung Wu knew she wanted to be a scientist, though she never imagined that she would work in a physics laboratory at Columbia University in America or anywhere else. She was just a happy little girl in a Chinese home in Liu Ho, a small town near Shanghai. She enjoyed the kind of life other little girls of her social group in China enjoyed. In one way, though, her life was different from that of many young people in her community. Her father, Wu Zong-Yee, was the director of a school in Liu Ho. Chien Shiung and her two brothers were surrounded with books, and they were urged to read. Though she was a child who loved to play, she did not have to be forced to read. In school and in her home she received from books and her surroundings the customs and learning of her country. She learned a lasting respect for them—respect for the old ways, for older people, for Chinese literature, and for the art and music of old China.

"It was a wonderfully happy life. I had a lucky and happy childhood," she says today.

When Chien Shiung completed school in her community, she was sent to Soochow for high-school work. Several things happened during her school days that were going to be important in her life. First, she began to study English, a language that would be necessary to her later.

More important, she decided to become a physicist. No unusual moment or event occurred to make her remember the time when she decided this. She wanted more education—in this she was a true daughter of her father. She liked her studies. And as she continued her high-school work, she realized that she liked some studies more than others. Certainly she liked mathematics and science. Then she studied physics and "I soon knew it was what I wanted to go on with." Something inside her told her so, she says.

When she had decided about her future work, she took the next step by becoming a student at the government-supported university at Nanking. In 1936 she completed her studies there and was ready for further study in physics, which China did not offer. Her parents allowed her to come to America for this purpose, so the autumn of 1936 found her at the University of California in Berkeley. Doctor Ernest Lawrence had just been made director of the **radiation** laboratory at Berkeley. Here this physicist was developing his invention, a machine for dividing atoms, called a cyclotron. Here he was doing research in atomic physics which brought him the Nobel Prize in Physics while Miss Wu was studying under him. Any young scientist interested in nuclear physics was lucky to study in Doctor Lawrence's laboratories at that particular time.

She had to learn about American life inside and outside the laboratory at the same time. She lived with other students from Asia and from all over Europe, and they gave her quick and understanding help. In time she learned to like American cooking—or some of it—and the social life, except for dancing. In time, too, she learned to like the music. A student of physics at Berkeley with her, Luke Cha-Liou Yuan, who became her husband later, is a music lover. He enjoys playing as well as listening to both Chinese and American music, and their home is a place where both kinds are often heard.

Although she may have had a few early difficulties in learning to like American life outside the university, no one needed to worry about her studies. She was able to do the difficult work demanded at the university and was asked to teach after only half a school-year. She continued to teach every year until she received her Ph.D. in physics in 1940.

The studies Miss Wu made in preparing her thesis were in two parts. In one study of radiation she showed great cleverness in creating new methods for separating two kinds of rays, and she was able to show good agreement between the experimental results and the theory. The other study, begun immediately after the fission of uranium had been announced at Berkeley, was on radioactive gases from uranium fission. She worked with another scientist, and they were able to provide important new information to physicists.

Doctor Wu had begun to show great abilities in nuclear physics before she completed work for her Ph.D., and the university offered her a job helping Doctor Lawrence in the Radiation Laboratory. Since the war situation in China was getting worse, she accepted it, and her researches in pure science continued for a while. Then the laboratory began to do war work, and in 1942 Doctor Wu went to Smith College to teach physics.

As her first year at Smith was ending, Princeton University asked her—a young woman of only twenty-seven—to teach nuclear physics to its men students. Doctor Wu says one of the strangest things she found in America (one that still surprises her since it opposes the American idea of equality) was the fact that some of the best universities do not accept women students. She explains this offer from Princeton with the words, "The war was on and there were few physics teachers."

She accepted the Princeton offer, but her time there was brief. After only a few months she was told that she was needed for work at Columbia University. To accept this offer would enable her to help more directly in the war effort. And at that moment she wanted to do this more than anything else. So in March, 1944, she became a member of the War Research department at Columbia. Until the end of the war her greatest efforts were toward the development of instruments for discovering the presence of radiation.

Soon after the war was over, Doctor Wu became a research associate at Columbia and found opportunity to continue her studies in the decay of certain particles in the atom called beta particles. Theories existed about beta decay, but theories must be proved. And methods for studying beta decay were very poor in 1946. In her laboratory at Columbia she began to find new methods of studying beta decay. These studies continued for a number of years. She was successful in developing new methods and she proved the Fermi theory of beta decay. Her studies also helped her to become an associate professor of physics at Columbia in 1952.

Students working with Doctor Wu had the opportunity to help in some of the best work in experimental physics being done in America. One after another, problems in beta decay, of radiation, and radiation-finding devices were studied. She was surprised, as were her students, at some of the results that came as her gifted mind found new ways to perform experimental work.

Her work was being followed with interest by other physicists. And in 1956 she had the opportunity to work with two young Chinese-American physicists whose work brought world-wide praise to American science and the Nobel Prize in Physics to the two young men.

These two were Professor Tsung Dau Lee of Columbia and Professor Chen Ning Yang of the Institute for Advanced Study at Princeton. They had been among the small group of physicists who, by the middle of 1946, had begun to have doubts about the truth of an idea known as the principle of parity. The principle of parity had been accepted as a law of physics for thirty years. This law had been built into all physical theories. It had been accepted so completely that it was almost unthinkable for a scientist to doubt it.

According to the law of parity, in the nuclear world an object and its mirror image act in the same way. To see the action of a mirror image, stand in front of a looking glass with a corkscrew in one hand and a bottle in the other. Turn the corkscrew in a clockwise motion until the cork comes out of the bottle. In the mirror the motion looks counterclockwise–and the cork comes out of the bottle. But if you tried the counterclockwise motion in the cork itself, the corkscrew would not go into the cork. Its action would be different from the way it appeared in the looking glass.

The law of parity said that, in the nuclear world, the real action of object and mirror image is the same. A few men had begun to doubt this. One reason for their doubts was because the decay of K-mesons did not occur in the way it should have according to the principle of parity.

Doctors Lee and Yang began a study of all that was known about parity at that time. They were surprised to find that the facts were not complete. They declared that the parity principle was in error. They proposed two different kinds of experiments to test their theory. Doctor Wu performed an experiment with beta rays for them. Her experiment was to see if the cork actually did come out of the bottle (that is, the particles fly off from the nucleus during decay) no matter which way the corkscrew turned (the spin, or turning motion, of the nucleus).

It was a very difficult experiment. A radioactive nucleus of the element called cobalt 60 was placed in a cooling device that could reach a very very low temperature. At this low temperature motion was so greatly reduced that the spinning cobalt nuclei could be formed into a line. In the instrument was a device which counted the electrons sent out by the row of cobalt nuclei.

When the electrons were counted, the law of parity was proved false. The number of electrons sent out in the direction away from the spin was greater than the number sent out along the direction of the spin. The number was so much greater that it was clear that electrons greatly favored going in the direction away from the spin of cobalt 60. Their direction seemed to be determined for them just the way the shape of a corkscrew determines whether it must be turned to the right or to the left. The experiment Doctor Wu and her associates successfully performed indicates that electrons have a "handedness." That is, they are called right-handed or left-handed depending on the direction in which they move. Their direction is determined by the motion of their spin.

High honors came to Doctor Wu when the value of her work became known. In addition to the honor from Princeton, she became the seventh woman member of the American National Academy of Science in its near-century of existence. She was also appointed a professor at Columbia, and she was elected to membership in the Academia Sinica (Academy of Sciences of China).

In March, 1958, she urged a group of science students in Washington to dare to doubt. "The story of the parity law shows that science is always growing and changing," she told them. "It is the courage to doubt what has long been believed, the continuing search for truth, that pushes the wheel of science forward."

One of her own doubts is whether America is developing abilities in physics in its young women. She cannot understand why so few young American women want to study physics. She cannot believe they lack ability when it appears so often in young women of other countries. She thinks it is unwise to continue attitudes in life that prevent young people from developing these abilities.

Her son will have his parents' best efforts to help him develop in physics or in any other way that his abilities suggest. She herself finds physics a satisfying field for any human being whose abilities are in this area.

EDITH HINKLEY QUIMBY

(1891-)

Physicist who helped create the new science of radiation physics, now important to good medical practice everywhere

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The story of Edith Quimby is the story of a woman who helped create the field of scientific work known as radiation physics. Every time X-rays are used to study parts of the body, every time radium or radiation treatments of any kind are given in a hospital, some part of Edith Quimby's work is used. Personally, or through books written by her, she has probably taught as many doctors who have become specialists in radiology as any other person in America today.

Edith Hinkley was born in Rockford, Illinois. In 1904, when she finished school there, the possibility of using X-rays and radium to treat diseases was only beginning to be thought about—and in only a few of the world's medical centers. The fact that powerful rays came out of radioactive substances in the earth had been learned only a few years earlier. Later this discovery would lead to new scientific understanding that would be recorded in high-school and college books everywhere. But when Edith was ready for high school, physics and chemistry were of the kind now called "19th century science." The radioactive age was too young for its results to have yet reached high-school books.

This was true, too, of the physics taught at Whitman College in Walla Walla, Washington, where she studied. However, before she left there in 1912 the laboratory work did include one experiment with radium and another with X-rays. Except for her inquiring mind, Edith Quimby might have become one of the thousands of young high-school science teachers of her day, content to read about scientific progress after it had been made, instead of helping to create that progress.

She was lucky in having a father who enjoyed her inquiring mind. Edith was one of those children who wanted to know why, what, and when; he did not tell her to stop asking questions. He urged her to find the answers somewhere else if he could not supply them or to work them out by herself whenever he thought she could.

She was lucky, too, in having a high-school science teacher who helped her to become interested in chemistry and physics and taught her to answer some of her questions in a laboratory. He was probably very important in helping her decide to study physics and mathematics in college.

Then, at Whitman College, she was lucky again. Not only did she have a scholarship for four years, she was also in one of the small American colleges where good teaching is done by professors who have close relationships with students. As a result, when she finished she knew she had only begun to learn about physics and she wanted to know more about it.

The Hinkleys, however, were a family with little money and with other children to be educated. It was time for Edith to earn her own money. She found a job as a teacher of chemistry and physics in the high school at Nyassa, Oregon. Two years later she went to the University of California at Berkeley, California, to continue her studies in physics. At the end of her first year at the university she married another student-physicist, Shirley L. Quimby. At the end of the next year she had finished her work, and the following September found them in Antioch, California. Here Shirley Quimby taught science in the high school and his wife stayed at home. One of her pleasures was cooking—another field in which an inquiring mind often produces very good results.

Nothing in Edith Quimby's life up to this time was out of the ordinary for a clever young woman with a college education. She was a gray-eyed young woman with light brown hair, five feet eight inches tall, of pleasant appearance, agreeable, and home-loving. She might have been any of hundreds of young women who were trained to teach, yet ready to give it up when or if the right man came along. Nor was it unusual that when America entered World War I she took her husband's job as a high-school science teacher when he went to war.

When his military service ended, young Mr. Quimby wanted very much to study for his Ph.D. in physics. No government aid existed then as it did later, to help service men pay for their education. Shirley Quimby found a part-time job that would pay him $1,000 a year while he studied. But two people cannot live and eat properly in New York City on that sum, and so Mrs. Quimby needed a job. They learned that the chief physicist at a New York City hospital, Doctor Giocchino Failla had plans for developing a radiological research laboratory at this hospital. They learned, too, that he needed a physicist to help him. Edith Quimby got the job and started to work with him in 1919.

No such science as radiological physics existed when these two began their work, even though radiotherapy—the use of X-rays and radium for the treatment of disease—was practiced in a number of hospitals. With the instruments and methods then used, this had dangers for the sick people and those giving the treatments.

A few physicists, working with doctors, were trying to learn how to apply the laws of physics to the use of X-rays and radium on human beings. Before much time had passed they realized that proper radiotherapy needed two new kinds of specialists—the radiotherapist and the radiation physicist. The radiotherapist would have to be a medical doctor, able to recognize and treat diseases. The radiation physicist would have to be a physicist, able to measure radiation exactly and able to operate the instruments used in treatments.

When Mrs. Quimby began her work with Doctor Failla, radium was still so scarce and so costly that their hospital was one of the few that had enough for research work. The first radium produced in America had not been ready until 1913 and it was so difficult to prepare that the first small amount of it cost $120,000. Not until 1916 had the American Radium Society been founded by doctors for "the scientific study of radium and other sources of radiations in relation to their physical characters and their medical uses."

Mrs. Quimby, still in her twenties, had opened the door to the new science of radiology. Twenty-one years later, with an honorary Ph.D. in science from her college, Doctor Edith Quimby arose in a meeting of the American Radium Society to receive its highest honor, the Janeway Medal. Except for Doctor Failla, she was the first person who was not a medical doctor to receive this medal. She is the only woman who has ever received it. It would be another eleven years (1951) before this society would award full membership to anyone who was not a medical doctor, even though physicists were needed for the society's work.

What Doctor Quimby had done for twenty-one years was to measure the different kinds of radiation so that doctors would know exactly how much to use. Though doctors knew that rays went into the human body and that some rays went deeper than others, no one knew exactly how deep and over what area.

Doctor Quimby was very largely responsible for discovering how much radiation was sent out from a certain source, how much was delivered in the air, how much to the skin, and how much within the body, under different conditions. Between 1920 and 1940 more than fifty reports describing her work were published. They contained practical information that might be put into immediate use anywhere treatments were given.

Many things became known year after year as more doctors used radiotherapy. It is easy to see how valuable a physicist's work could be to these medical specialists. For example, two people might have the same kind of tumor, or unnatural growth, but with one deeper than the other. In the early days of radiotherapy, if a doctor gave the same amount of radiation to both people he might know that the results would be different. But he himself did not have the training to know how to vary the treatments to get the same results.

The accurate measurements Doctor Quimby was making showed that one of these tumors might actually be receiving twice as much radiation as the other. The amount delivered to the tumor depended upon how deep it was below the skin and on a number of other things, such as the size of the area receiving radiation and the distance of the X-ray source from the body.

It is not surprising that doctors gave a medal to Edith Quimby after she had spent more than twenty years helping to make it possible to use radiation accurately in the treatment of disease. Actually, some of these doctors did more than give her a medal; they obtained a job for her at Cornell Medical School, which had a close association with the hospital where she and Doctor Failla were working.

This teaching job came in 1941. That same year she received the Gold Medal of the Radiological Society of North America, an award no other woman except Marie Curie has received. Doctor Quimby's award stated that her work placed every radiologist in her debt. It placed many sick people in her debt, too.

When she began to work at Cornell she had more opportunity for teaching doctors. Radiology had become a specialty in medicine, and Doctor Quimby was more able than medical doctors to teach some parts of it.

An even greater opportunity came in 1943 when she received an associate professorship at Columbia University, where Doctor Failla was also teaching. Her full professorship in this great medical school came in 1954, the year she served as president of the American Radium Society. By this time the Society had brought radiation physicists to equality with medical radiologists in radiological science.

As radiotherapy was used more and more widely in hospitals, safety became more important too. When radioisotopes began to be used for medical treatments in the late 1940's, this also meant danger to those who used them. Doctor Quimby studied the best ways of working with radioisotopes. Her studies included safe methods of handling the radioisotopes, protection for nurses in caring for people receiving this kind of treatment, and safety measures in handling the bodies of persons who die within a short time after receiving treatment. She became a recognized expert in the handling of radioactive wastes in hospitals and in methods for cleaning up if an accident occurred.

She has helped in three ways to build a new science: (1) in making it possible to give exact amounts of radiation to sick people; (2) in showing how to avoid radiation dangers; and (3) in teaching the physics of radiation treatment to doctors who want to become radiologists. But that would be only a part of the whole story. Her personality—the kind of human being she is—has been almost as important in building this science as her work.

Doctors who work with the sick do not easily accept as equals those who are not medical doctors. The medical doctor has long assumed responsibility for sick people, and others work under his direction. Yet the understanding of science needed for the practice of medicine today has become so vast that the individual doctor cannot learn all of it.

Radiotherapy required that highly educated physicists and highly educated doctors work together without either directing the other. This was a task for which a certain kind of personality and a certain kind of skill in physics was of value. In Doctor Quimby this personality and scientific ability were combined in one person. She, as much as any other person, won from leaders in the medical world an equal place for radiation physicists in the field of radiotherapy.

As a result of her work and that of a few others, a new field for the physicist is now established. It is a field in which many women are doing good work, though men are in the majority. It is one in which a Ph.D. in physics is a help. It is one which is limited by the number of hospitals that give modern radiotherapy and the number of colleges teaching it. But it still offers more opportunities than there are trained physicists to fill them.

Honors have come to Edith Quimby—too many to be listed here—and the end of them is probably not in sight. She has been asked to serve on the Atomic Energy Commission's committee for the control of radioisotopes and on the National Committee for Radiation Protection. She has long been one of the members of the American Board of Radiology, which names doctors as specialists in radiology.

A life outside her work has always been necessary for Edith Quimby. As soon as her husband had his Ph.D. (he has been a member of the department of physics at

Columbia University ever since) they found a home in New York City. And they still live there. Here Edith Quimby has done a wife's share in creating a home, and she works at it regularly. That home is a center for living quite apart from her work life—a place where she reads and plays card games, makes many of her clothes, and enjoys preparing meals for her husband and their guests. These home tasks—the things so many women who now work outside the home enjoy—are her pleasures, too.

Vacation time usually takes both Quimbys out of their home and away from New York. She and her husband like to travel and they make a trip outside the United States almost every year. They fly, if there is need for it, but they prefer to go by a slow ship. She enjoys seeing things she does not see in New York and renewing friendships with many friends in Europe and South America. These things complete an active life for this woman whose work has helped open new opportunities for young scientists today.

JOCELYN CRANE
(1909-)

Zoologist whose studies of small animals have taken her to hot jungles, mountaintops, and to islands of the seas

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She always loved animals. The smaller the animal, the more she seemed to love it. By the time she was six, she knew she wanted to work with them all her life. That memory is still clear in Jocelyn Crane's mind today.

Anyone who knew this small girl soon learned what kind of book to give her for a gift. Anything about animals pleased her, and the smaller the animals, the more she was pleased. Pictures of crabs or bees—pictures of any little creatures—could hold her interest a long time.

When she learned to read, she was soon searching for all she could find about foreign countries. Asia began to interest her—especially its hot regions. She can never be sure whether it was Asia itself or all the small animals living there that made her want to go there as soon as she could. Not to the cold lifeless regions of northern China or Tibet, not to the Himalayan mountains, but to the jungles in the warm countries of Asia. Then she learned about the jungles of Africa and of South America, and she wanted to study every small living thing that lived there.

Seldom do small children know as well as did Jocelyn Crane what they want to do. This is especially true when, as in her case, no one in her family had ever done these things. Fewer still begin to do exactly what they want to do as soon as they are old enough to begin work at it. Still fewer are as certain in middle life that what they wanted to do at the age of six was exactly right for them. "I was one of the lucky ones," she says.

Lucky—yes—but Jocelyn Crane's early schooling might have been a difficult situation for many children. When she was six and ready for school, her family left St. Louis, where she had been born. And she scarcely stopped moving for the rest of her school life. Her first six years of school were spent in eleven different schools as far apart as Washington, D. C., and Los Angeles, California—from the east coast to the west coast. She moved so often that teachers, friends, and buildings are mixed up in her mind today.

Just as she had known at six that she wanted to work with small animals, she had known for several years that she wanted to go to Smith College. Her teachers knew she wanted to study zoology. Though zoology was not taught in her high school, they had given her physics, chemistry, and mathematics, which any science student needs. They knew, too, that Smith offered excellent work in zoology. So in the fall of 1926 a tallish blue-eyed girl arrived in Northampton, Massachusetts. She knew why she was there even though she could not choose her major study before the end of her second year.

She could, of course, study zoology during her first year. She loved it and did very well at it. And she did very well in all her other studies, too. In her second year she took another zoology course and one in astronomy—for a jungle traveler may someday need to know about the stars. Then her teachers suggested that she take a special course in zoology in her third year. As a student working for special honors she did not have to take any tests until the end of her fourth year, she had weekly meetings with professors, special laboratory work, and she prepared a thesis based on her own research.

Jocelyn Crane will always be grateful that Smith understood her particular needs and gave her wonderful opportunities for preparing for the life she wanted. Not just one teacher but a number of them helped her to get the best Smith could give her. During her last two years she took everything the college offered that had a direct or indirect relation to a zoologist's life. She also studied literature, art, and other subjects. In 1930 she finished her work, receiving highest honors. She left immediately for New York City and a job with the New York Zoological Society.

She soon found herself at the Zoological Society's Research Laboratory at Nonsuch Island, Bermuda, working with William Beebe. Doctor Beebe had recently begun to use the bathysphere, a hollow steel ball, to go deep into the ocean to study the strange creatures that live there.

She accompanied him to this place six or eight times in the next ten years. Every day they went out on a boat that traveled over the area of ocean where the bathysphere would be lowered and where animals would be collected in nets. Life provided an entirely new kind of excitement when she was invited to climb into the 54-inch hollow steel ball, fit herself into the space for the second passenger, and begin the trip through greenish water.

With eyes held next to the window as small creatures swam past, she watched the color of the water change to blue-green and then a darkening blue. Little flashes of light from sea life appeared as the water changed to a darker blue. Now came the fun of watching colorful animals, some of them truly ugly and strange, as Beebe pointed strong rays of light into the darkness.

Each year Miss Crane was more and more sure that the actions of small animals while they were alive interested her most. Also, she had begun to observe crabs, and she discovered how much their action patterns interested her. She wanted to study these creatures because she felt sure the things they were doing might help reveal secrets still hidden from human minds. The social habits of small animals became her main interest now.

Now she had to decide her future plans. Should she take her Ph.D. or go ahead without it? Though she decided against a Ph.D. she does not recommend this to other young women. She says:

"It has worked out well for me because I have been able to stay on with the Society and Doctor Beebe and do the work I wanted to do. If I had suddenly needed to find a new job ten or fifteen years after college, my lack of a Ph.D. might have prevented me from getting the best opportunity. I took that chance and I am glad I took it. But I honestly could not recommend others to take it. I was lucky!"

Lucky—yes—because five years after college she was able to take her first trip to Asia. She lived in a village in Kurdistan for a few months to study insects living in the mountains near it. One day a small boy reached inside his red jacket and brought out just what she had been wanting—a gray-furred baby squirrel from a nest in a tree where it had recently been born. It was too young to have watched how other squirrels act. Miss Crane wanted to see how it would act if taken from its natural home and cared for without having to look for food.

Three days later in the room where she was working, the baby squirrel became frightened and ran into her fireplace where a fire was burning. It came out quickly, ran up her stone wall, and hid in a hole. Not until its suppertime was she able to bring it down again. Its fur was burned a little but to her great joy it was not truly harmed. She named it Shadrach and tied a soft ribbon around it so it would not run away while she watched its actions outside the house. She soon learned when a dog or a strange person was coming because Shadrach quickly climbed into her pocket to hide.

But he did not fear all animals—at least not when he met them inside the house. One evening while she was working she heard a noise and saw two large-eyed wild rats coming in through a hole in her door. They carefully moved toward some nuts left from Shadrach's supper. Shadrach was sleeping near the nuts. He wakened, put first his nose and then his whole head out of his bed, and looked at the rats. They stepped back. Then Shadrach went back to sleep. The rats finished his supper, departed, and returned the next evening and most evenings until Miss Crane and Shadrach departed for America. Apparently he was not only unafraid of rats but was willing to share the food for which he had never worked.

Following her studies in Kurdistan, the Research Department's field station for two years was on a boat in the Gulf of California and eastern Pacific Ocean. Miss Crane studied crabs along the coast of lower California and the west coasts of Mexico and Central America. Stopping at places all along the way, she made collections of crabs to take back to New York for study. But first she studied them alive.

Their colors, ranging from brilliant red to dark brown, mixed with yellow and yellow-green, were very interesting. The outer shell of one female that she caught on a dark stormy day was a purple-gray when it was caught. After it had sat in a sandy-bottomed box in the sun for a couple of days, it was a bright pink. She found, as is true in some other animals, that the adult male crabs were brightest in color, the females paler, and the young ones palest of all.

She watched hundreds of crabs dig their holes and found that they built them in three different patterns. The crabs had different ways of carrying their sand loads and pressing the sand to make their homes. She watched the crabs as they appeared at the doors of their homes as soon as the high tide began to go down. Resting for a few minutes first, they then cleaned themselves. After an hour had passed, the crabs, beginning usually with the largest, started toward the edge of the tide to eat what the ocean had washed up for them.

Before the tide began to advance again, they came back to their homes to repair old ones or build new ones, feeding as they worked. "Then the crabs gradually returned to their holes, usually pulling in sand after them. Fifty minutes before high tide not a crab would be left on the beach." High tide, low tide—and the story was repeated day after day.

This was only the beginning of her work on these seashore creatures that are found all over the world. And she can make crabs so interesting that most people who hear her talk or see her pictures stop wondering why she has spent so many years studying them. To her, crabs are not something to eat, but one of a group of little animals whose social habits always interest her. She became an expert in making movies in color for the best study of animals whose coloring seems to have a great deal to do with their social life.

The first dozen years of Miss Crane's work life had not sent her to the jungles she had dreamed of visiting as a child. But in 1942 the Research Department established a field station near Caripito, Venezuela, for a year. The work was so successful that it was decided to build a station in the jungles of South America. Miss Crane now had the opportunity to travel in parts of Venezuela, Columbia, and Ecuador to find the best place for the station.

A job of this kind is not without physical hardships. Getting off a plane, she would get into a saddle and spend days on horseback traveling in jungles. Other days were spent on lakes and rivers studying their jungle-lined shores.

In the Andes, and later in Trinidad, she studied butterflies, insects with large, brightly colored wings. She has long been curious about the bright coloring of some of the small animals. Is this coloring ever of use in their social relationships? Miss Crane does not know the complete answer, but some of her work with butterflies has given part of the answer. She removed the dustlike substances that give color to the wings and painted them another color. Males would give no attention to a female when her wings were painted black. Both males and females thought butterflies made out of orange-red cloth were real. So color does, sometimes at least, make animals act differently.

After World War II was over Miss Crane was able to get back to Asia, visit the South Pacific and then Africa. Early in the 1950's the National Science Foundation gave her money to spend a third of her time each year for five years making a world-wide study of certain crabs.

The result of this long study promises to be the most colorful and complete scientific report ever made on this subject. Nor will its interest be limited to scientists. The oneness of the life force and the development of man and of animals are subjects that interest the minds of many thinking human beings.

Jocelyn Crane works for the joy of what she is doing. In no way has this lessened the respect in which her work is held by other scientists. She believes that studies of the actions of living animals are valuable help in understanding the development of all animals.

To help in these studies is her aim. However, it is not the main force behind her work. She has a strong need to know more about small living creatures, and she labors mostly to satisfy her own need. Young enough to have the possibility of much good work ahead of her, she is likely to keep on doing the things that can satisfy that need.

FLORENCE VAN STRATEN
(1913-)

Who has helped in developing America's modern Navy *Weather Service*

Meteorology is a young science. Its aim is complete understanding of all the physical processes that combine to produce "the weather." In short, meteorology is the science of the atmosphere, or air surrounding our earth.

Except for weather forecasting, the ability to tell what future weather would be, meteorology had hardly begun to advance before World War II. Florence van Straten was pushed into this new science by her superior officers when she joined the Navy after the United States entered the war. She has been in it ever since, first as a U.S. Navy officer and, since 1946, as a private citizen in the Office of the Chief of Naval Operations. In these positions, she has been responsible for some of the advances that are moving this young science step by step toward its aim.

One of the things Florence van Straten brought to this young science when she joined the U.S. Navy was a Ph.D. in physical chemistry. Within five weeks it had assured her a place in the first group of 25 women selected for training in aerological engineering (the navy words for meteorology).

Yet Florence van Straten had never planned to use her abilities in the physical sciences until her last half-year in high school. She had grown up knowing exactly what she wanted to do with her life, and it had nothing to do with science. She was going to be a writer. Hers was a good home for a young writer's development. Her parents came from Holland. Her mother spoke six languages very well (and was the highest salaried woman in Holland before she came to America). Her father wanted to help his only child prepare for any kind of work that she preferred.

His work for Metro-Goldwyn-Mayer, a movie company with its main offices in New York City, sometimes took him outside the United States. This gave Florence an opportunity to spend one year of her school life in Nice, where she improved her French. (She always spoke English and Dutch equally well.) All this and German, Italian, and Spanish learned from her parents—"I haven't needed to go hungry in any of these languages ever since"—was excellent experience for a young writer.

But writing is not something you decide to do, go to college to prepare for, and then earn a living at. Florence knew that writers do not usually earn enough money to live on until they are older. This had special meaning for Florence because she finished high school when she was only sixteen.

Added to this, Jacques van Straten, always a strong influence in his daughter's life, had had an experience as a youth that taught him life does not always become what a person plans. He wanted to became a doctor. He was just beginning college when his wealthy family suddenly lost its money and he had to go to work without preparation. Therefore, he suggested to his daughter, "Why not use some of your time in college to prepare yourself to make a living in some work other than writing—just in case you ever need to?"

The idea was so reasonable that Florence quickly accepted it. But she had no idea what a second choice of work would be. She still had half a year of high school ahead of her, so she decided to study chemistry. "I liked it as I always liked what I studied; so if Dad and my high school principal thought it was an area in which I could always earn a living, it satisfied me, too."

That autumn she entered New York University with English and chemistry as her two major subjects. She had the choice of taking her degree in either subject. She never dreamed that degree would not be in English.

As she was beginning her last year in college an event changed the direction in which she was going as unexpectedly as the course of her father's life had been changed. A teacher became ill and Florence was asked to teach one of his laboratory classes in chemistry. She taught the class the whole year. Spring came, and with it the offer of a teaching job for the next year. But she would have to take her degree in chemistry instead of English, and she would have to study toward a Ph.D. in chemistry.

She thought it over carefully. She was only nineteen.

All experience was material for a writer. She accepted the offer and took her degree in chemistry in 1933.

During this period Florence van Straten, who had been writing stories all through high school and college, discovered she was completely unable to write. Her experience with science had influenced her so much that the scientific approach seemed the only honest approach to truth. Within a few years, however, she understood that "the serious writer and scientist each seeks truth in his own way. Though I am first a scientist, I believe art is another way of searching for the truth the scientist is trying to express. Truth must be one whole, not little sections marked 'truth of science,' 'truth of religion,' and 'truth of art'."

As this became clearer to her, she found herself beginning to write again. In this she follows the pattern of many other famous scientists who have an interest in one of the arts and find it wise, maybe even necessary, to keep this interest alive.

She remained at New York University for nine more years taking her Ph.D. in physical chemistry there in 1942. But the specialized study by the Navy had shown her that meteorology, now changing from an art to a science, offered interesting opportunities.

At this time the U.S. Navy was fighting on two oceans. Especially in the Pacific there was need of greater understanding of weather conditions, and of how to use the known facts in the best way. Weather has often had a great deal to do with the results of naval battles. The Naval Weather Service's job was to make sure that ships did not meet surprise weather conditions and to use weather conditions to advantage in winning battles. The job was difficult because, in the Pacific, the Japanese knew more about weather conditions than the United States did.

Dr. van Straten's job would be to develop new methods to enable weather officers on ships to tell commanding officers every day—even every hour—what the weather conditions would be, as far in advance as possible. To give an example of what was needed:

When planes are sent off from the deck of a ship, the ship must move into the wind, and the combined speed of wind and ship must be above a certain figure. It is necessary to find the right winds, to keep the ships at safe distances from a battle, and have ships and returning planes meet again in another favorable wind condition. The weather officer must know the weather conditions if this is to be done properly.

In one battle in the Pacific, Japanese planes found the ships just as the last American planes were coming back to the airplane carriers. Since planes are faster than ships, the problem was to get the ships away from the Japanese planes if possible. The weather officer found the answer. He determined the position of a "cold front" some distance away. This weather condition produces clouds just above the surface of the water that would offer a natural hiding place. The ships proceeded to the location he recommended, and stayed inside the cold front. Japanese planes hunting for them could be heard in the sky above. After many hours the planes left, and the ships went safely back to Pearl Harbor.

Forecasting weather conditions on or near the earth's surface is much more difficult than forecasting conditions higher in the atmosphere. Untrained people find it easy to laugh when the weatherman's forecast is wrong, but Doctor van Straten says this happens less often than we think. "It's just that everyone remembers the wrong forecasts and forgets the right ones."

The meteorologist knows it is easier to forecast correctly the conditions a plane will meet in flying from New York to Los Angeles, for example, than to forecast conditions at either of these cities. Conditions near the earth's surface are more changeable because of all the local effects. To be really right in forecasting for a twenty-four to thirty-six hour period, he must have all necessary facts. But he does not know all necessary facts.

By the time the war was over, Florence van Straten was truly interested in the study of weather. Her superior officers in the Naval Weather Service realized she was needed for their work. There were few scientists who were as able as she was for this kind of work. And as the years passed she helped to find answers to many different kinds of problems.

One of her first big jobs came about because many scientists working on long-range missiles designed to enter the upper atmosphere did not realize that they needed help from meteorologists. They forgot that conditions in the atmosphere would affect their missiles. The Naval Weather Service believed that a study of the upper atmosphere would reveal facts that would affect the design of long-range missiles. They decided to study wind and temperature conditions up to a height of 100,000 feet. Then came the announcement that the work would be directed by Doctor F. W. van Straten.

It was a large task, as anyone who looks at the four thick reports that came from Doctor van Straten's office must realize. Her job was to study thousands of facts discovered in many different ways. Facts from many different locations, from Greenland to Japan, came to her desk. The results of her studies were presented over a period of two years, for immediate use by scientists.

These studies made missile people aware of their need for help from meteorologists. The theory that when a missile entered the stratosphere (30,000 to 40,000 feet above the earth), it entered a calm, storm-free area was shown to be false. Light, gas-filled bags called balloons were sent up to 100,000 feet with weights hanging from them. A 70-pound weight shook greatly in the stratosphere, and winds were strong enough at 65,000 to 70,000 feet to push a 55-pound weight upward so forcefully that it broke the balloon. Any missile that entered the stratosphere had to avoid these winds or be prepared to enter them safely.

Methods for using balloons for gathering facts about wind and weather have improved since those studies were made, and Doctor van Straten has been one of the scientists responsible for this. By the middle of the 1950's the Navy was sending up 40-foot balloons every day in Japan. These balloons are very thin, yet they carry more than 600 pounds of instruments. They rise to 30,000 feet and float at that height. Every two hours they report their position, temperature, and other facts. Traveling with the winds, they cross the Pacific Ocean, pass over the United States, then cross the Atlantic Ocean and destroy themselves as they approach Europe. Thus wind speeds are known every day for the whole distance they travel.

One result of Doctor van Straten's ability was that she was given considerable freedom to work on any problem she believed important. In this way she began to study certain problems of radioactive fallout. This is particles of matter which stay in the air after an atom bomb has burst. Sitting at her desk in Washington in the Office of the Chief of Naval Operations, she thought: "Suppose Washington were bombed. How could authorities know the best ways to save lives and move hospitals and supplies to the safest possible place?"

Radioactive particles, she knew, follow fallout patterns that are influenced by conditions in the atmosphere. Fallout is heavy in some areas and light in others. The amount varies with the passing of time. She developed a scientific method for determining radioactive fallout patterns under any weather conditions. If determined every day, this would enable authorities in any area to know immediately how to get the people to a safe place in case of an attack.

The method was not very costly or difficult to put into effect, but a question existed in many minds whether radioactive fallout was a real danger. So Doctor van Straten put her plan away and turned to other matters. Then, a year or so later, it was learned that some Japanese fishermen had suffered serious harm from radioactive fallout following an atomic test in the Pacific. Immediately people all over the world were alarmed, and the government needed to know how to determine the fallout patterns.

Florence van Straten presented her plans again. They were what was needed.

She had recognized the problem and found an answer without being asked—or told—to do it. As a result of her work, every day weather officers on land or sea can determine the pattern radioactive fallout would follow that day if a bomb were dropped in their areas.

Doctor van Straten's work has become broader than the limits usually given to meteorology. This was recognized in 1958 when she was named "Woman of the Year" by the women's group of the Aero Medical Society for her work in atmospheric physics. She believes meteorology offers an interesting field and enough opportunity to more young women than have yet entered it. In the middle 1950's only about two per cent of all meteorologists were women. Though weather forecasting is the best known part of meteorology, she believes research and other kinds of laboratory work, and teaching, probably offer better opportunities for women.

In any part of meteorology, mathematics and the physical sciences are required for college work. Ph.D.'s are still not too frequent among meteorologists, though they are needed for work such as Doctor van Straten has done. Meteorology is a scientific field whose future promises more than its past has yet accomplished. Weather making and control of outer space are no longer subjects only for the imagination. They are problems of serious scientific study in which meteorologists are going to have a share of the work.

GLADYS ANDERSON EMERSON
(1903-)

Biochemist whose researches with animals have increased our understanding of the effects of a lack of vitamins on the human body

Nothing in Gladys Emerson's early life indicated what her future was going to be. When she was still a baby her parents moved from the small town of Caldwell, Kansas, where she had been born, to Texas. She grew up without a brother, a sister, or any desire or need to study hard in school. Learning from books and teachers came easily. She started early to find time to get fun out of life. And though her ideas of what was a good time changed as she grew older, she never found reason to change that early pattern of work and play. When, in 1956, she moved to a new home and a new job at the University of California in Los Angeles, she took with her a piano, three or four cameras, a collection of music, and the hope of finding a new dog to take the place of her old one that had died.

Like many other schoolgirls, Gladys Anderson, as her name was then, was interested in most of the subjects she studied and had no favorites. She found she shared her mother's ability in mathematics and her father's interest in history. In high school she discovered she liked Latin and chemistry as much as she liked mathematics, history, and the social sciences. At times it seemed as if she enjoyed public speaking best of all. She sometimes thought the theater might offer what she wanted.

Her interest in the theater did not last past her first year at Oklahoma College for Women in Chickasha, Oklahoma. The college theater group decided to produce a play. Gladys imagined herself as playing the part of a beautiful girl, but she was asked to be a young boy. That was the end of her dreams of the theater.

During her college years, as in her high-school days, she found no single study that appealed to her more than did a number of others. At Oklahoma she took two degrees—one in physics and chemistry and one in history and English. She was president of student government. She taught chemistry and physics for two years. But she found time to play the piano and missed very little of the fun at college.

She had her choice of helping to teach in either the science or history departments and she chose science. After finishing her work at Oklahoma College for Women she went to Stanford University in California for a year of further study. There she helped to teach in the history department. The next year she became head of the department of social sciences in a school in Oklahoma City, Oklahoma.

Then, at the age of twenty-three, Gladys Anderson took the step that would lead to the Garvan Gold Medal for her work in chemistry twenty-six years later. Two teaching opportunities offered themselves, one in social sciences and the other in the physical sciences. She chose the latter, which was at the University of California in Berkeley.

By the end of that year's work at Berkeley, she knew that it was biochemistry that interested her. After three years of teaching at the University of California and one at Iowa State College, she returned to the University of California and took her Ph.D. in animal nutrition and biochemistry in 1932. During this period she married another scientist.

One lack in her education as a biochemist was an inability to read or speak the German language with ease. Much scientific work was published first in German, and German would be a help at scientific meetings, too. Also, young Doctor Emerson believed that living in a foreign country would be a good experience for her. So she decided upon a year's study at Gottingen University.

That year at Gottingen was not as pleasant as she had hoped. The second World War was coming. Although conditions became increasingly uncertain, Doctor Emerson formed friendships that year at Gottingen that she was able to renew after the war ended. Many of the Gottingen group became leaders in the reorganization of German universities, science, and industry.

Living and working there for a year and a half did not help her to speak German with ease.

"I can read it easily enough," she says, "and I can manage to speak well enough to make myself understood. But it is painful to the ear and I know what it must sound like to a person who knows the language well. Nevertheless, I try to speak German every time I go to Europe—and people always answer me in perfect English!"

Her lack of ability to speak German did not affect her ability to do her work with animals when she got home. The spoken word was not important.

In the United States the next year Doctor Emerson took charge of nutrition research at the University of California's Institute of Experimental Biology. She studied what animals could show about the effects upon human beings of chemical substances in our foods. White rats were then and still are most often used for many kinds of experiments. Food and medicines produce effects in them similar to man.

The institute in 1933 was doing research on vitamin E. It was already spoken of as the "reproductive vitamin" because when rats ate food that had too little vitamin

E, they lost their ability to reproduce themselves. It seemed, then, as if lack of vitamin E was the cause. If so, might lack of vitamin E have the same effect on human beings? This was a problem that needed further study. It was known that vitamin E existed in grains, vegetables, meat, and milk, and that the center part of wheat was especially rich in it. This fact was particularly interesting. In some parts of the world young married women eat a handful of wheat every day to assure success in bringing healthy babies into the world.

Today scientists tell us the need for vitamin E in human nutrition has not been determined. If wheat does help successful childbearing, it is probably not because of its vitamin E. Such statements could not be made, however, until scientists could study the individual vitamin. In nature it is always combined with other substances, so it had to be separated from them before work could be begun.

Gladys Emerson worked with other research workers to separate vitamin E. Not only did they succeed in doing this, but by 1936 they had found three different forms of the vitamin. Wheat oil, corn oil, and cotton seed oil were used as sources. Then vitamin E was made in the laboratory and new studies compared the effects of the laboratory-made vitamin E with vitamin E prepared from natural sources. Results of these studies showed the same strength for the natural and laboratory-made vitamins. The Berkeley scientists were ready for their studies with animals. They hoped that their findings might benefit human beings.

Though the value of vitamin E in human reproduction is still not known, work soon showed that it actually is needed for the successful reproduction of rats. One study showed how the ability of rats to reproduce became less when their food lacked vitamin E. This ability would return when vitamin E was again given to the female rats.

Another study with vitamin E showed that muscular dystrophy, which appeared in baby rats fed by mothers who lacked vitamin E, could be prevented by beginning to give the vitamin to the mothers on the days their babies were born.

Mr. George W. Merck made frequent visits to the institute during these years. At that time he was president of Merck and Company, whose laboratories are famous for making medicines. Connected with this company was an institute where similar work was being done. Mr. Merck and several of the Merck Institute scientists knew Doctor Emerson's work and personality and decided that she would be valuable to their institute. In 1942, at the age of thirty-nine, Doctor Emerson found herself in New Jersey as head of the Merck Institute's Department of Animal Nutrition. There she had greater freedom to do her work than is usually possible at a university.

In making this change Doctor Emerson was entering the world of industry in which so many young women are now employed. She had a Ph.D. and years of experience in which she had developed skill in scientific research. She had shown leadership and ability to get along easily with people. With this to offer she was ready for this greater opportunity.

One part of her new job would be to train young women in the methods of experimenting. Trained workers were becoming more and more necessary, for the country was already at war and the need for women in scientific laboratories was increasing.

Her early researches at Merck, still with white rats, were largely concerned with the B vitamins. New facts about these vitamins were being discovered. There proved to be at least seven (possibly more) of these vitamins that had at first been thought of simply as vitamin B. Different kinds of diseases were produced by the lack of different vitamins in this group. Rats and dogs that ate foods lacking in these vitamins developed eye and skin sicknesses. And study of their dead bodies sometimes showed unnatural conditions inside their bodies. It was important to learn how each condition could be lessened or even cured by the right amounts of vitamins.

All this work with vitamins and her later studies on tumors, or unnatural growths, were leading to the research work which Doctor Emerson has found most interesting. As a biochemist—and the "bio" means a chemist who studies the effects of chemical substances on living bodies—she became interested in the effects of certain food substances in producing arteriosclerosis. This is a disease which causes a hardening of the arteries—the vessels which carry blood from the heart through the body. It is common among older people and often makes death come early. She worked with monkeys to learn more about this disease. The monkeys were wild little beasts, and working with them had some danger.

Scientists had long believed that monkeys were similar to humans in their food habits and that they got similar nutritional diseases. This belief was strengthened in the 1950's after scientists studied Bushman, the famous gorilla at Chicago's animal park who had died after a seven-month illness at the age of twenty-two. Though he had been fed carefully, he had become very fat and had developed arteriosclerosis and a disease resulting from the lack of some of the B vitamins. Studies of his dead body revealed still other conditions in Bushman's body believed to be caused by a lack of certain food substances.

Though gorillas and human beings do not have exactly the same food needs, studies of Bushman's body gave scientists reason to believe their researches into the cause of arteriosclerosis were going in the right direction. In the Merck laboratory they were using dogs and monkeys in this work. They fed them food lacking some vitamins to produce hardening of the arteries. Then they gave them substances which they hoped would make the arteries normal again.

To describe a little of how these studies in arteriosclerosis were made: The group at Merck fed fifteen monkeys food lacking vitamin B_6 for periods varying from four to fourteen months. At different times the animals were killed and their bodies studied. Arteries had begun to harden as early as four months, and other parts were affected. In the first animals killed these diseased conditions could be seen only with a microscope. In animals killed after longer periods, the conditions were seen by the unaided eye. Vitamins were then given to live monkeys with the same conditions. After a certain period these animals, too, were killed and studies made of their arteries and other parts. These animals showed facts that may bring benefits in treating human illnesses. The interest that the Merck company has in this kind of research may be seen from the fact that the animals are sometimes given the names of Merck officers. The officers consider it an honor to have monkeys named for them.

In 1956 an offer came for Doctor Emerson to return to the University of California as a university officer. She was unhappy at the thought of leaving her researches, especially in arteriosclerosis, but the new job would not require much actual teaching. Also, she was assured she could continue to give advice to Merck. Merck also offered to give the university twenty-nine monkeys so she could continue her researches.

Gladys Emerson was still in her early fifties when she moved to her new home in California. Behind her were almost a hundred published reports giving results of her work and the work she had done with others. Ahead of her were many hopes, including the hope to work with the World Health Organization; UNICEF, the United Nations organizations to help children; and other organizations in finding new ways to provide better nutrition for parts of the world now poorly fed.

Doctor Emerson believes that women do not lack opportunities in chemistry. Ability and a good education are needed for advancement. She is popular with other women chemists and is one of the few they have honored by electing president of their honorary society, Iota Sigma Pi.

Her friends say her future will not be all work. One of the first things she did in Los Angeles was to get a dog. She was soon helping to organize a group to sing folk songs together and play music on all kinds of instruments. She soon discovered how much she enjoyed watching ball games—an early love that had long been forgotten. These, and other pleasures, including travel, are planned for the years ahead. She also plans to have time for her friends, who find her a good companion outside, as well as inside, the laboratory.

DOROTHEA RUDNICK
(1907-)

Embryologist ***whose delicate method for transplanting embryo sections is helping to reveal new facts about growth and development***

As a young girl Dorothea Rudnick did not like science, especially laboratory science. The story of her life between birth and the age of nineteen indicates that, of all the things she might have chosen to become, a scientist was not one of them.

Life began for her in Oconomowoc, Wisconsin. Her older brother and younger brother both became physicists and her father was a chemist. To use her words, "I grew up in a home where we breathed a scientific air."

She was not unhappy about this. It soon become clear to her that science was interesting. But she did not think it was interesting enough to become her own lifework. Too many other possibilities offered themselves—though she did not know which of them appealed to her as a lifelong occupation.

Her high school gave students some choice in what they studied. And Dorothea had some very definite ideas about what she did and did not want to study. History and languages were her main interests, and she chose these studies as often as possible. She took mathematics because her older brother told her she would enjoy it. She did not want to study chemistry or physics. Since the high school did not require them and she could enter the University of Chicago without them, she did not study these subjects. She does not recommend that high-school girls today do this.

In addition to the fact that she had no interest in science, several other facts were clear about this dark-eyed, dark-haired fifteen-year-old girl. First of all, her mind had been developing faster than most. Also, she did not fit easily into the pattern set by her family and followed unquestioningly by most young people of her social group. Going to college was not what Dorothea Rudnick wanted to do most. First she wanted to go to Europe for a year.

That was not possible, and she could understand why. She knew how young she was, even though fifteen and a half seemed older to her that summer than it ever would again. She felt that she should not ask for the money because education for her brothers was costly. As a chemist, her father would never be a rich man.

So she tried to be happy at the University of Chicago as she began her work in languages there in 1922.

The languages were mainly French and Italian, though German was the language her grandmother and grandfather spoke. She enjoyed university work. She found a completely unexpected interest in geology, the study of the earth's surface. "I'm glad Chicago did not let me do all the choosing," she says, "for I would have missed geology if it had not been a requirement." College was quite interesting, but nevertheless, after two years she left school. She was seventeen and a half—old enough for a job—and she wanted to earn money of her own. By working and saving for a year, she could afford a year outside America.

Finding a job in Chicago in 1925 was not difficult. Her parents permitted her to save what she earned. She had a friend whose family would be living in Europe the next year, so Dorothea and she planned to travel together for a while. But Dorothea definitely planned to travel alone for much of the time.

So at eighteen this young woman was on her way to Europe, paying with her own money. She was beginning a wonderful adventure. She was doing what she wanted to do most, at a time when she was young enough to enjoy it to its fullest—even the frights and difficulties, if they came. She had time to see and do many of the things she wanted to see and do, including some mountain climbing, and a visit to Paris, alone. She lived there for a few months.

All of it was done as cheaply as possible so that it would continue as long as possible. "In Paris I allowed myself ten dollars a week," she says, "and actually I was rich. Most of the people I knew there had only five dollars a week." By being careful with her money she was able to stay for a year and a half. Friends must surely have felt sympathy for her parents while Dorothea was having her wonderful experiences. For what parents would not worry a little about a daughter, away seeing the world at eighteen? But the end did come, and she was back in Chicago in the middle of the second winter after she had left it.

She now spent some unhappy months. She knew she had to decide what kind of future she should prepare for. If she could have gotten a writing job, possibly she would have done that. But, as Florence van Straten had realized, "You can't just decide to be a writer, study it a few years, and then make a living at it." So Dorothea Rudnick, trying to understand the force within her, finally decided that it was going to be science of one kind or another. She wished that she had recognized it earlier.

By this time she had learned at least one thing about herself. "I knew I could not live on other people's experience alone. I had finally recognized that I needed the experience a laboratory would give me." So she decided to go back to the university. She would continue to study languages, but take some science—probably biology, though the particular subject did not matter much at the moment.

She also decided that no matter what she studied, she was going to have a good time. There can be little doubt that Miss Rudnick was becoming a young person with a sense of personal responsibility, and a need to understand herself if she were to develop to her fullest.

What happened then was unexpected. In her study of zoology she became interested in the many different forms found among animals. To her, embryology—the study of the development of these forms—seemed to be most important. She began to study embryology and discovered tools for understanding the life history of animal forms. Embryos became beautiful and wonderful objects which, properly questioned, might share their secrets. She hoped to learn how to ask the right questions. In short, "Embryology interested me. It still does."

She worked hard and progressed rapidly. She soon found the special problems within embryology which have remained her first interest ever since.

Embryology is concerned with animals in their embryo stage, which lasts in humans for the first three months after the beginning of life and in other animals for shorter or longer periods. Miss Rudnick studied the form of animals with the idea of following a process of development. She became interested in learning what caused one tiny part, or parts, of an embryo to develop into a foot, another into a right ear or tail feather. She tried to find out when and in what order these things happened.

When she looked at an egg after it had been broken into a dish, she knew that the yolk, or yellow part, was food for the embryo and baby chicken while it was in the shell. The little white spot that always stays on top of the yolk interested her. This was the living protoplasm—the matter which becomes the living animal. She knew that this tiny piece of living protoplasm contained substances that would develop into every muscle, bone, and other part of a feathery baby chicken. Exactly where, she wondered, was the particular thing in that tiny piece of protoplasm that would develop into the chicken's left eye or right foot? Even more important, what caused each tiny thing to develop as it did, when did the process start, and how did it proceed?

Early in her work she began to develop delicate methods for transplanting certain bits of one embryo to another. This work brought her fame. The method was not new, but only a few scientists can use it successfully because of the great skill it requires.

One of her methods was to transplant parts of one embryo to another embryo and determine, by careful study, what happened and when. In the summer of 1942 she was ready to begin research to answer this question:

Can the part of a very young embryo that would form a leg develop into that same sort of leg if transplanted to another embryo?

For her experiment Doctor Rudnick chose embryos of White Leghorn chickens into which she could transplant selected parts from embryos of Creepers, a kind of short-legged chicken. One-fourth of Creeper embryos die in the shell. Of this one-fourth, the embryos that live long enough to develop legs at all have very, very short ones.

In the laboratory, the White Leghorn eggs were kept warm and the embryos allowed to grow for about 60 hours. The Creeper embryos were allowed to grow for only 24 to 30 hours. Each White Leghorn egg was held up to a light that showed where its embryo was. The location was marked on the shell. With a tiny knife Doctor Rudnick cut a small window in the shell around this spot and left the window in place, to be removed later. Then in a dish containing a warm salty liquid, she broke one of the Creeper eggs. Using her microscope, she separated its embryo from the yolk and flattened it.

With a glass needle she separated a piece from the right and another from the left side of a part in the embryo's center, including the leg-forming area. She then removed the window from the first egg, tore the underlying layer a little and held it back with tiny tools. She pointed the light of her microscope on the embryo inside and cut a tiny hole in its side. She then picked up one piece of the Creeper embryo (the other part would be placed in a second Leghorn embryo). Working under the microscope, she put the embryo piece into the hole. Then the window was replaced in the shell.

The complete operation required ten to fifteen minutes. "It's not very difficult," she says.

If not difficult (for her!), it must surely be hard work to do such research well because so many eggs must be worked with. Her published report in 1945 on this experiment does not tell how many eggs were used in it.

But it does say 159 embryos were still alive when they were studied six to fourteen days after the transplanting. Of the 159 living embryos, 93 showed a successfully transplanted part. Nearly one-third of them showed recognizable leg or wing parts, growing from practically any part of the White Leghorn chicken.

When the legs were examined they showed that a leg transplanted to another embryo would be the same as if it had developed in its own embryo.

Another question was answered too. This was: Is the unnatural shortness of the leg caused by something within the leg-forming area or by something from outside that area? To find her answer to this, she had taken pieces of leg areas from Creeper embryos before they developed a blood system. In one-fourth of the successful transplants the legs were very, very short—the same number that develop but die in the shell. Thus the condition was shown to be caused by something in the area itself.

This study of the development of leg material had followed studies of other parts of chicken embryos. She had also done some earlier work on rat embryos which showed that rat embryos could go through part of their development outside the mother's body. In one of the experiments, 100 successful transplants were performed and their results reported. Doctor Rudnick's greatest interest was in chicken embryos, however. The Guggenheim Award she received in the early 1950's enabled her to devote almost a year to further studies with these embryos.

The research for which the Guggenheim Award was granted was on enzymes that affect the production of protein in the chicken embryo. She had been interested in the development of the liver, the center of protein manufacture in the adult animal. Embryos take protein from the egg yolk and use it as body-building material. Now she wanted to study the activities of enzymes in starting the manufacture of the protein by the living embryo. How early, she wanted to know, can the enzymes be found in a developing liver?

The work was done with two other scientists. They succeeded in tracing the history of the enzyme they were studying, finding it appears first outside the embryo, in the covering of the egg yolk. After the embryo's liver appeared, it was found there, and much later, in the brain.

This led Doctor Rudnick to study the nervous system of the chicken. But first she finished her Guggenheim Award year with four or five months outside America. She visited laboratories in Europe to see and learn about work in embryology there. She worked for six weeks in a laboratory in Strasbourg, and taught briefly in Bologna, using the Italian language. "With much help," she says.

Doctor Rudnick is one of the scientists who enjoy both teaching and research. She has opportunity for both. She teaches at Albertus Magnus College in New Haven, Connecticut. It is only a short distance from the Osborn Zoological Laboratory at Yale University, where she has a small laboratory in which she does research. This is done mostly on Saturdays and Sundays and during vacations. When an experiment or research requires it, however, she is at Osborn for an evening's or late afternoon's work.

Albertus Magnus is a small college with only a few hundred students—all of them women. The quality of the work it offers in biology is shown by the many scholarships earned by its science students.

Doctor Rudnick has served as editor of a book published every year by the Society for the Study of Growth and Development. The book contains reports of the newest advances in this field. She also enjoys writing. She is a recognized authority in her field of embryology, with the possibility of years of good work ahead of her. She feels certain that embryology will continue to interest her.

GLOSSARY

(Meanings given are only those for the sense in which a word is used in this book)

ACADEMY: a group of learned men who work to advance science or art; also, a school.

ANTIBIOTIC: a substance that destroys *bacteria* and is used in treating diseases.

ASTRONOMER: a scientist who studies stars and heavenly bodies.

ATOMIC: concerning the ATOM: the smallest part of an element that still has the special qualities of that element.

AWARD: a prize or honor.

BACTERIOLOGY: the science that studies BACTERIA: tiny living things that are so small they can be seen only with an enlarging device. Some cause diseases.

BIOCHEMISTRY: the science that studies what plants and animals are made of and how they act under different conditions.

BIOLOGY: the science that studies living things and how they grow.

BOMB: a powerful military device that releases great force and heat when it bursts.

CAMERA: a device for taking pictures.

CHEMISTRY: the science that studies substances to find what they are made of, how they act under different conditions, and how they are used to form other substances.

CLOCKWISE: the direction in which the hands of a clock move; COUNTERCLOCKWISE: the direction away from the way clock-hands move.

CORKSCREW: a device for removing a CORK: a piece of soft tree bark used to close bottles.

CRAB: a sea animal with a broad, flat shell and eight legs.

DECAY: to break apart gradually.

DOCTOR: a person who has received the highest degree given by a university in an advanced study, including medicine.

ECLIPSE: the hiding of all or part of the sun by the moon when it passes between the sun and the earth.

EMBRYOLOGIST: a scientist who studies the development of the EMBRYO: an animal in the first parts of its growth while it is in the egg or the mother's body.

ENZYMES: a substance produced in plants and animals that causes changes in other substances but is not changed itself.

FISSION: a breaking apart.

FOUNDATION: an organization that supports scientific studies.

FUNGI (Sing. FUNGUS): simple plants that have no leaves, flowers or green color. They grow on living or dead plants and animals.

GENES: tiny bits of matter that carry the physical qualities of parents on to the children. GENETICS: the science that studies genes and their effect.

GLOBULAR STAR CLUSTER: a ball-shaped group of stars separated from other groups by vast distances.

GORILLA: a very large, strong animal, shaped somewhat like a man.

JUNGLE: wild land thickly covered with trees and plants, usually located in the hot countries.

LABORATORY: a room or building where scientific work and tests are done.

MATHEMATICS: the science of numbers.

MEDAL: a small flat piece of metal with words or designs on it, given as a prize or honor.

MEDICAL: concerning the science of medicine.

MICE (Sing. MOUSE): small animals with long tails found in houses and fields everywhere in the world.

MICROSCOPE: an instrument which makes tiny objects seem larger when it is looked through.

MIRROR IMAGE: the likeness of an object as it is seen in the shiny surface of a looking glass.

MISSILE: an object which is shot through the air.

MONKEY: small man-like animals with long tails and four feet that are used like a man's hands.

NAVY: a country's military sea forces. NAVAL: concerning the Navy.

NUCLEUS: the center of an *atom*. NUCLEAR: concerning the nucleus.

NUTRITION: the processes by which an animal or plant takes in and uses food.

OBSERVATORY: a building with instruments for studying stars.

PARTICLE: a very tiny bit of matter.

Ph.D: the highest degree a university gives for advanced study. Persons with this degree have the rank of "doctor."

PHYSICS: the science of energy and matter that studies the way things are moved and work is done.

PHYSIOLOGY: the science that studies living things and the way their parts work.

PROTEIN: a substance found in all living things and in certain foods, which is a necessary part of an animal's *nutrition.*

RADIATION: the process in which energy is sent out from *atoms* because of changes inside them; also, the energy that is sent out.

RADIOACTIVITY: the process by which energy is sent out from certain elements as a result of the breaking-up of the center of the atoms.

RADIOISOTOPE: an element which is not naturally *radioactive*, but has been made so by man for use in treating disease.

RADIOLOGY: the treatment of disease by using *X-rays* and *radioactive* substances; RADIOLOGICAL: concerning the science of radiology.

RATS: animals similar to *mice*, but larger.

RESEARCH: careful, patient study to find new facts and principles about a subject.

SCHOLARSHIP: a gift of money to help a student continue his education.

SERUM: a liquid from the blood of an animal that has a certain disease. It is used as a medicine to fight that disease.

SQUIRREL: a small animal that lives in trees, and has a long, bushy tail.

TELESCOPE: an instrument that makes distant objects, such as stars, seem larger and nearer when it is looked through.

TRANSPLANT: to remove something and make it grow in another place.

VITAMIN: a substance found in food, which is needed by the body to keep healthy.

X-RAYS: rays which cannot be seen but which can pass through objects. The yare used to study the bones and other parts inside the body.

ZOOLOGY: the science that studies animals and animal life.

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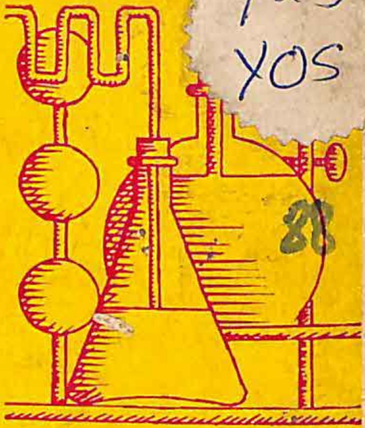
WOMEN OF MODERN SCIENCE



28

**WOMEN are winning
more and more important places
in the 20th century world.**

**Here are the lives and works of
11 WOMEN SCIENTISTS—
European, Chinese and American.**

**WOMEN OF MODERN SCIENCE
tells the human stories
of their struggles for PROGRESS—
for their SEX
and for SCIENCE.**

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